Natural Community Systems of New Hampshire

Daniel D. Sperduto

New Hampshire Natural Heritage Bureau
and
The Nature Conservancy

New Hampshire Natural Heritage Bureau

DRED – Division of Forests & Lands
PO Box 1856 – 172 Pembroke Road, Concord, NH 03302-1856
(603) 271-2214

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The New Hampshire Natural Heritage Bureau is an excellent source of information on plants and natural communities in New Hampshire, including their ecology and distribution in the state. It maintains the state's only comprehensive database of New Hampshire's exemplary natural communities, rare plants, and rare animals, including their known locations. Rare wildlife locations are maintained in cooperation with the Nongame and Endangered Wildlife Program at the New Hampshire Fish and Game Department, which has legal authority over all wildlife in the state. The bureau is also a member of the NatureServe network, which connects nearly 80 Natural Heritage Programs throughout the United States, Canada, and several Latin and South American countries. The Nature Conservancy provides ecology staff and other services to the bureau through a cooperative agreement with the state of New Hampshire.

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Cover photo: **Northern hardwood - conifer forest system** at lower elevations of The Bowl Research Natural Area and Mt. Passaconaway (Waterville Valley) transitions to **high-elevation spruce-fir forest system** at higher elevations. The former system consists of a mixture of ***sugar maple - beech - yellow birch forest*** and ***semi-rich mesic sugar maple forest***; the latter system consists of ***high-elevation spruce - fir forest*** and ***high - elevation balsam fir forest***. In places, patches of more mixed ***northern hardwood - spruce - fir forest*** community mark the transition between the two systems. Photo by Dan Sperduto.

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SUMMARY

Natural community systems are particular sets of natural communities that repeat in the landscape and are linked by a common set of driving forces, such as landforms, flooding, soil attributes, and nutrient regime. Systems describe how natural communities pattern into larger units in the landscape and thereby provide a broad-scale way of approaching communities. For instance, there are five natural communities that are often found together on peaks above 4,900 feet elevation in New Hampshire. Each individual community corresponds to a particular combination of exposure, substrate, wetness, and snow depth, but all five share the overarching force of an extreme climate and short growing season. The combination of these individual communities forms a larger "alpine tundra system." In this document, 46 natural community systems (20 upland and 26 wetland) are described for the state of New Hampshire.[1] The diagnostic characteristics of each system, such as vegetation, ecological conditions, distribution, and component natural communities are described.

Natural community systems are coarse-scale, intuitive units that can be understood by a broad spectrum of users and are at an appropriate scale for many conservation applications. They reflect major ecological differences and patterns in the New Hampshire landscape that can be used as broad "coarse-filter" units to help identify conservation priorities. They don't replace natural communities; rather, they are an aid in understanding the larger context for multiple communities at a site, including identification of ecological factors that control the communities and that are important for long term site protection needs. Natural community systems also correspond well to wildlife and wildlife habitats, are at a practical scale for mapping and predictive modeling, and can be used in conservation planning to identify the most significant sites in need of protection at local, state, and regional levels.

[1] These systems were previously described in two separate reports "Upland Natural Community Systems of New Hampshire" (Sperduto 2004a) and "Wetland Ecological Systems of New Hampshire" (Sperduto 2004b) — and have been combined in this document. In addition, one newly described system has been added and two others have been merged. In the wetland natural community systems classification report, these systems were referred to as "ecological systems." *"Ecological systems" and "natural community systems" are synonymous.* We have adopted the latter name because it emphasizes and reinforces a key concept about these systems: they are simply groups, or *systems,* of natural communities that repeat in the landscape.

INTRODUCTION AND BACKGROUND

Natural communities reflect important biological differences in the landscape. When used as conservation targets, natural communities serve as efficient "coarse-filters" for protecting many plant and animal species, including obscure species that are not readily identifiable. This coarse-filter approach to conservation has been a key motivation in both the collection of detailed field inventory data across the state and the development of the current classification of 193 terrestrial, palustrine, and estuarine natural communities (Sperduto and Nichols 2004). In turn, this information has been distributed to partners who have protected many ecologically significant sites in New Hampshire.

The development of this information has also lead to some important observations about the size and diversity differences among natural communities. Key among these is the observation that most of the landscape is covered by only a few “matrix” forming community types (the cookie dough), whereas a relatively small portion of the landscape harbors the majority of the community types as small to large “patch” communities (the chocolate chips) within the matrix. Further, certain patch communities tend to occur together in the landscape where similar recurring conditions are found. The specific patterns and combinations of natural communities that form these sets of matrix and patch communities are the subject of this document.

We have called these coarser scale units “natural community systems.” Each natural community system is based on particular sets of communities that recur in the landscape and that are linked by a common set of underlying or driving forces. These forces include landscape setting, environmental features (e.g., hydrology, soils, and nutrients), and ecological dynamics (e.g., fire and flooding). Natural community systems form cohesive and distinguishable units on the ground and recur in similar settings. Many of the patterns described in the New England Natural Community Classification (Rawinski 1986), the first classification system used by NH Heritage, are validated in this current classification of natural community systems. However, the newer classification is defined and scaled according to analysis of considerable field data collected since the older classification was devised.

The need to formerly describe natural community systems has emerged for several reasons. First, as our more detailed knowledge of natural communities has grown, so has the need for a broader ecological context above the scale of individual communities -- essentially the need for a “coarser coarse-filter” to illuminate a big picture perspective. Basically, the large number of communities and the complexities of their distribution, size, and rarity calls for the ability to simultaneously evaluate both detailed information and broader patterns in order to prioritize among sites on the ground. Second, conservation practitioners often have limited capacity to interpret detailed community data and require the bigger picture context of a site or sites because they operate at large geographic scales involving many sites, entire states, or broader regions. Third, wildlife have relationships to plants and natural communities in different ways and at multiple scales: some are keyed into individual species or natural communities; some are keyed into a particular structure found within one or more communities; and some correspond to different habitats or sets of communities at different points in their life cycle. Defining coarser-scale units above that of individual natural communities likely will have good correspondence to many wildlife species and their habitats. We anticipate that natural community systems will have numerous practical applications among conservation practitioners, five of which are discussed below.

- **Practical scale for conservation.** Natural community systems are at a practical scale for a wide range of conservation applications. Conservation planning and site prioritization at state and regional scales, ecological research and monitoring, and GIS mapping and modeling endeavors will all be facilitated by using natural community systems as a complementary tool to natural community and

species approaches. Natural community systems allow conservation targets (e.g., wetland sites) that consist of many to sometimes dozens of communities to be referred to as a single system. Systems will greatly facilitate comparisons among sites and will focus attention on the key ecological features of each site. In addition, they occur at a more appropriate scale for modeling and mapping than many community types. Finally, natural community systems will facilitate ecological classification of sites, through interpretation of limited field data or predictive mapping, when detailed field data are not available or readily collected.

- **Understandable to a broad audience.** Natural community systems will facilitate communication among a wide range of conservation practitioners. There are many fewer natural community systems than there are natural communities. In addition, the driving factors that link groups of communities in the landscape will be integrated into the concept and name of each system (e.g., montane acidic talus, kettle hole bog, and high-gradient rocky riverbank systems). As such, communication among a wide range of conservation practitioners from botanists to landowners will be facilitated through a common language of intuitive ecological units that describes New Hampshire's landscape. Natural community systems will provide a "big picture" view of the biological landscape of the state and region.
- **Applicable to a broad region.** The New Hampshire natural community system classification will be widely applicable to other parts of the glaciated northeast and north-central North America. New Hampshire is at the interface of several major biogeographic regions (i.e. alpine, boreal, temperate, and coastal), and systems described from the state should be broadly applicable or closely related to those from the Great Lakes to Pennsylvania, New England, and the Canadian Maritime region.
- **Links to wildlife habitats and plant and wildlife modeling.** Natural community systems have direct utility and applicability to wildlife and rare plant species conservation and management. Although natural communities are effective "coarse-filter" units for capturing many invertebrate species (e.g., insects, soil micro-fauna) and other obscure life forms, birds and mammals often utilize multiple communities at a site or can respond to structural characteristics that occur across many communities. Thus, in some cases the best match for wildlife and wildlife habitats will be the system, rather than individual communities. The same can be said for relationships to rare plant species: some species occur in a broader range of habitats than that found in one community type and are more well represented at the system scale. Systems will also be at a more appropriate scale for predictive range mapping for some rare wildlife and plant species. For example, the habitat description for the rare northern bog lemming (*Synaptomys borealis*) identifies conditions that might occur in 25 or more communities in New Hampshire. However, these habitat descriptors would correspond to perhaps only a few natural community systems. If we wanted to predict the full potential range of northern bog lemmings in the region and locate new occurrences, we might begin by overlaying known populations with the known or probable range of these systems.
- **Evaluating conservation priorities.** Ranking criteria can be developed to evaluate the quality of individual examples of natural community systems. This can be done in the same manner as for ranking communities (e.g., using size, condition, and landscape context attributes) and will enable comparisons and conservation prioritization among sites. Ranking natural community systems makes a great deal of practical sense since evaluating the quality of a site and identifying conservation and protection needs almost always requires thinking beyond the scale of an individual community. Ranking specifications were developed and applied to open peatland systems in New Hampshire (Sperduto et al. 2000b), but have not been specifically developed yet for many other systems.

METHODS

Our overall approach to developing the natural community system classification involved three major phases: 1) drafting a broad, preliminary system classification; 2) validating and refining the draft classification based on more detailed, site-specific field and GIS data; and 3) developing final descriptions of each system. We began by conducting a review of literature relevant to natural community systems development in New Hampshire (Kangas 1990, Brinson 1993a and 1993b, Vitt 1993, Semeniuk and Semeniuk 1995, Zoltai and Vitt 1995, Noble and Gitay 1996, Jorgenson 2000, and Goebel et al. 2001). We then structured the middle and higher levels of a hierarchy based on broad, driving forces that structure ecosystems (e.g., hydrogeomorphic classes, nutrient regimes, and landform features, etc.). These are well documented in the literature, and are both discussed and utilized in the New Hampshire natural community classification (Sperduto and Nichols 2004). We then established preliminary guidelines for defining specific natural community systems found at the lower levels of the hierarchy, and produced a draft classification of these systems. The draft was based primarily on first-hand observations and knowledge concerning distribution patterns of natural communities in the state. The draft was then validated and refined by reviewing GIS-based spatial information, considerable field data available at NH Heritage, and additional literature review to finalize and describe the system units.

The most basic attribute of natural community systems that we emphasized in the classification development is that they are spatial units: *natural community systems are groups of natural communities that co-occur in the landscape and that are linked by common driving forces*. This contrasts with categorical groupings of communities that may share certain environmental attributes but do not actually occur together on the ground because they do not overlap geographically. While we considered many environmental attributes and descriptors of communities and larger systems, such as biogeography, soil conditions, and hydrogeomorphic setting (among others), we did not use these variables in a formal "forcing" way that dictates the distinction of a new ecological system with each categorical shift in major variables (i.e., using biogeographic or climate regions to indicate an automatic shift in system type, as in the original New England natural community classification (Rawinski 1984)). Rather, we looked for spatial patterns of co-occurrence, and described and named these units using the attributes that were most useful in explaining the pattern. For example, while there are some biogeographic differences among riverbanks in different climate regions within the state, we concluded that river gradient and energy level are more important variables in describing patterns in these riparian systems across the entire state. In contrast, biogeographic or climate regions were more useful in describing distribution patterns of swamp and forest communities. Once the systems were defined, they were then described in terms of associated natural communities and a broad variety of environmental descriptors for each system. These environmental descriptors are relatable to the larger body of literature concerning natural community systems (some of which is referenced above). Thus, New Hampshire natural community systems are based solely on spatial patterns observed in New Hampshire, but validated by and set into an ecological framework that is more broadly applicable at regional and global scales.

We validated and refined the draft system classification by reviewing data on well over one thousand site locations in the New Hampshire landscape. At each location, we identified the natural community type and adjacent associated communities at the site. To accomplish this, we first rectified all the known occurrences of exemplary wetland natural communities recorded in the NH Heritage Biotics database to the newly revised natural community classification (Sperduto and Nichols 2004). In a similar manner, we also compiled observation points from data that are not in the NH Heritage Biotics database, and reviewed and classified them according to the current natural community classification. We then used all of the data from these site observations to clarify and revise our guidelines for defining systems in general

and for refining specific system type concepts and descriptions. Ultimately, we cross-referenced and changed all the old names for exemplary natural community occurrences in the NH Heritage Biotics database to the new system or community classification name. All exemplary natural communities were attributed to the particular system they correspond to.

Following the completion of the New Hampshire classification, we conducted a limited review of the NatureServe ecological systems classification (NatureServe 2003) to determine whether there were major differences in approach and possible gaps in coverage of either classification with respect to New Hampshire. The NatureServe classification is the initial draft of a first-of-its-kind attempt to classify ecological systems (= natural community systems) for most of North America. Although the utility of a unified continental-scale classification is clear, detailed analysis of site-level data from each state was not feasible for a classification of such a broad scale. Consequently, we chose not to build our system classification directly upon the results of that broader effort, instead focusing on specific and detailed data available for New Hampshire. This ensures a relatively good closeness-of-fit to the state's landscape, and a certain level of independence from the NatureServe effort. In our limited review, we found a mixed correspondence between these two classifications. Most of the broad-scale hierarchical levels are similar and many of the systems are more or less synonymous or relatable to one in the other classification. However, some parts of the two classifications emphasize different environmental variables, patterns, or scales, and therefore end up with units that are not closely comparable. Where it is advantageous to do so, these differences can likely be resolved with future revisions to both classifications.

RESULTS

The major results of this project are twofold: 1) the classification approach and descriptions of upland and wetland natural community systems (presented in the next sections); and 2) all upland and wetland exemplary natural community records have been updated to reflect the new classifications (systems and communities). A summary of key distinguishing attributes and driving forces of natural community systems is found in Table 1.

In developing the classification system, we came up with some basic guidelines and assumptions about the definitions of systems and their application to mapping. These are described below.

- **The primary criterion for defining natural community systems was a pattern of co-occurring sets of communities in the landscape that are linked by common driving forces.** Two systems are indicated instead of one when the ecological conditions and driving forces are substantially different and corresponding sets of natural communities occur independently of one another. For example, riverbank systems are considered distinct from floodplain systems, in part because they can occur independently of one another and in part because there are substantial and well defined hydrological and community composition differences between the two. The types of floodplain communities on a floodplain are not perfectly correlated with the types of communities in its adjacent riverbank (the two sets of communities can occur independently of one another), and some riverbanks have no adjacent floodplain. Community composition along river channels and riverbanks is distinct from that on adjacent floodplains because the frequency and intensity of flooding differs. River channels and riverbanks are flooded frequently or for extended periods each year; the lowest floodplains worldwide are on average flooded only once every 1-3 years.
- **Natural community systems can contain a broad array of ecological conditions and vegetation structures.** Some natural community systems contain a broad array of ecological conditions and vegetation structures, particularly in settings where gradients are steep and

compressed into narrow zones (such as river and pond shores) or where the corresponding natural communities are almost always found together and do not occur independently of one another (such as open and forested floodplains, mosaics of alpine tundra communities, and sandy pond shores with shrubby and aquatic vegetation). While the ecological conditions are variable, they are more or less continuous, and a clear ecological boundary representing different driving forces that would distinguish two systems is generally not present. In addition, the communities are almost always found together. In contrast, some systems have a narrow range of ecological conditions and structures, such as temperate acidic talus or black spruce peat swamp systems. While this latter system is often found in association with poor level fen/bogs, it is also frequently found in isolation of open bogs and therefore described as its own system.

- **Natural communities have different levels of fidelity to natural community systems.** We list natural communities that can be found in a system according to two broad categories: those that are *diagnostic*, and those that are *peripheral* or *occasional*. Diagnostic communities are those that are restricted to or characteristic of a particular system. They may or may not occur in a particular example of a system, but the system is the primary or one of the few primary systems in which the community occurs. Peripheral or occasional communities are those that can occur within a system but are not present in most examples; among these, peripheral communities are those that tend to occur within the system in ecotone areas adjacent to other systems. Some communities can be found in several systems, but most are found primarily in only one or two types of systems.

- **For pragmatic reasons, we accept that delineations of natural community systems may contain inclusions of other systems, or natural communities that are more typical of other systems when** 1) the included systems or communities are small or marginal (ecotonal) to the primary system at a site; or 2) when the included system or community is so finely embedded or tessellated within the primary system as to make its delineation impractical. For instance, there is often a narrow zone of a medium level fen or marsh communities along the upland edge or open water borders of an otherwise poor level fen/bog system; or a narrow ring of black spruce peat swamp around large poor level fen/bogs. Whether a system is delineated as a separate system within a larger wetland complex will depend on: 1) its size and degree of embedded-ness (a practical consideration); and 2) its conservation significance (i.e., whether the example is large enough and in good enough condition to be exemplary in and of itself and therefore a conservation target of interest).

- **Natural community systems complement, rather than replace, natural communities as coarse-filter conservation units.** Natural community systems are essentially "*coarse* coarse-filter" units; they incorporate large-scale biodiversity differences in the landscape, including many community types and species. However, there are important biodiversity features and patterns that will be missed if systems are focused on to the exclusion of communities (e.g., see our comparison of prioritizing peatland site protection using systems vs. natural communities in Sperduto et al. 2000b). Communities can be used in a complementary way by helping to identify important differences and patterns among system examples, such as rare natural community types that are found in only a few examples of a system type.

Note: Rare species listed in this document are followed by an asterisk(*).

Table 1. Natural Community Systems of New Hampshire: Terrestrial

Coarse Hydrologic Regime	Dominant Structure	Mineral Enrichment	Landscape	Substrate/ Landform	Elevation	System
Terrestrial (upland)	Open to Woodland	Low	Hills and Mountains	Summit/ridge	> 4900 ft. (-4200)	**Alpine tundra system**
				Ravine	> 4200 ft.	**Alpine ravine/snowbank system**
				Summit/ridge	3000 - 4900'	**Subalpine heath - krummholz/rocky bald system**
				Cliff	> 1000 ft.	**Montane cliff system**
					< 1200 ft.	**Temperate cliff system**
				Outcrop/shallow bedrock	1300 - 3000 ft.	**Montane rocky ridge system**
					< 1200 ft.	**Appalachian oak rocky ridge system**
				Talus/loose rock	1500 - 3500+ ft.	**Montane acidic talus system**
					< 1800 ft.	**Temperate acidic talus system**
			Lowlands/ Valley Bottom	Sand and gravel	< 1000 ft.	**Pitch pine sand plain system**
				Sand dune	< 50 ft.	**Coastal sand dune system**
				Rocky shore	< 15 ft.	**Maritime rocky shore system**
	Forest	Low to Moderate	Mountains	Loose and firm till	2500 - 4500 ft.	**High-elevation spruce - fir forest system**
			Mountains, high hills, and mountain valleys	Loose and firm till, glacio-fluvial	1400 - 2500 ft.	**Northern hardwood - conifer forest system**
			Mountain valleys and lowland flats	Firm till, glacio-fluvial	1000 - 2500 ft.	**Lowland spruce - fir forest/swamp system**
			High to low hills, mountain valleys, and lowland flats	Loose and firm till, glacio-fluvial	< 1500 ft.	**Hemlock - hardwood - pine forest system**
			Hills, valleys, and lowland flats	Loose and firm till, glacio-fluvial, marine silt/clay	< 900 ft.	**Appalachian oak - pine forest system**
		Moderate to high	Concavities and lower slopes of hills and mountains	Mesic loose and firm till, glacio-fluvial	< 2600 ft.	**Rich mesic forest system**
			Hills and lower mountain slopes	Dry-mesic loose till, talus, or loose rock	500 - 2000 ft.	**Rich north-temperate talus/rocky woods system**
					< 900 ft.	**Rich Appalachian oak rocky woods system**

Table 1 (part 2). Natural Community Systems of New Hampshire: Palustrine, Riparian, Estuarine

Coarse Hydrologic Regime	Substrate	Dominant Structure	Mineral Enrichment	Hydrogeomorphic Setting & Water Source	System
Palustrine	Primarily Organic (peat & muck organic layer > 16")	Open	Oligotrophic	Depressional, closed or near-closed, topogenous	**Alpine subalpine bog system**
					Kettle hole bog system
					Poor level fen/bog system
			Weakly - mod. minerotrophic	Depressional, open, topogenous/limnogenous	**Medium level fen system**
			Mod. - strongly minerotrophic	Sloping, open, soligenous	**Montane sloping fen system**
					Patterned fen system
					Calcareous sloping fen system
		Wooded	Oligotrophic	Depressional, near-closed, topogenous	**Black spruce peat swamp system**
					Coastal conifer peat swamp system
					Temperate peat swamp system
			Minerotrophic	Depressional, open, soligenous	**Near-boreal minerotrophic peat swamp system**
	Primarily Mineral (organic layer < 16")	Wooded	Minerotrophic	Depressional & sloping, open, topogenous/soligenous	**Temperate minerotrophic swamp system**
					Lowland spruce - fir forest/swamp system
				Sloping, open, soligenous	**Forest seep/seepage forest system**
		Open	Minerotrophic	Depressional, open, limnogenous	**Emergent marsh - shrub swamp system**
	Mineral - Sand & gravel	Open	Oligotrophic	Sand plain pond border, limnogenous/groundwater	**Sandy pond shore system**
				Depressional, closed, topogenous & groundwater or perched	**Sand plain basin marsh system**
Riparian	Mineral	Open	Oligotrophic to moderately minerotrophic	River channels and river banks	**Low-gradient silty-sandy riverbank system**
					Moderate-gradient sandy-cobbly riverbank system
					High-gradient rocky riverbank system
		Wooded	Minerotrophic	Floodplains	**Montane/near-boreal floodplain system**
					Major river silver maple floodplain system
					Temperate minor river floodplain system
Estuarine	Peat & Mineral	Open	Minerotrophic	Protected embayments, tidal rivers, intertidal	**Salt marsh system**
				Tidal rivers, intertidal	**Brackish tidal riverbank marsh system**
	Mineral			Exposed embayments, tidal rivers, intertidal	**Sparsely vegetated intertidal system**
				River channel, creek, and bay-bottoms, subtidal	**Subtidal system**

Water Source notes: topogenous = influenced by surface runoff; limnogenous = influenced by lake, pond, & stream water; soligenous = influenced by groundwater seepage.

Open rock controlled systems, clockwise from top left:

1. Alpine ravine/snowbank system (left foreground) at the head of Madison Gulf w/ ***black spruce – balsam fir krummholz***, ***alpine heath snowbank***, & ***alpine cliff*** communities; alpine tundra system on flats/slopes of Mt. Madison beyond Star Lake (background). Photo DDS.
2. Stunted jack pine in ***jack pine rocky ridge*** community within montane rocky ridge system on Welch Mtn, Waterville Valley. Photo DDS.
3. ***Cliff seep*** community within a montane cliff system in Devil's Hopyard, Stark. Photo DDS.
4. Montane acidic talus system with ***subalpine cold-air talus barren*** (left foreground), ***spruce – birch – mountain maple wooded talus*** and ***lichen talus barrens*** (middle ground), and montane cliff system (top) on Whitewall Mtn., Zealand Notch. Photo DDS.
5. Montane rocky ridge system on Orange Mtn. in Cardigan Mtn. State Forest. Outcrop opening within ***red spruce –heath – cinquefoil rocky ridge*** community with hair grass and lichens in foreground. Photo BDK.

CLASSIFICATION OF UPLAND NATURAL COMMUNITY SYSTEMS

OPEN TO WOODLAND SYSTEMS ON BEDROCK- OR SAND-CONTROLLED LANDSCAPES

ALPINE AND SUBALPINE SYSTEMS

Alpine and subalpine tundra vegetation in New Hampshire is restricted to largely treeless, high-elevation peaks and ravines of the White Mountains, a few scattered high-elevation monadnocks in central and southern New Hampshire, and several lower-elevation, cold microhabitats. The alpine zone above treeline is characterized by a severe climate and communities dominated by low mat-forming shrubs, sedges, rushes, grasses, mosses, and lichens. The vegetation is exposed to high winds, a short growing season, low temperatures, heavy cloud cover and fog, high precipitation and fog interception, and occurs on mostly well drained soils with low nutrient availability and high organic matter content. In New Hampshire, climatic treeline occurs at approximately 4900 ft. elevation. However, alpine and subalpine vegetation can be found at lower elevations due to local compensating factors (i.e., wind-exposed ridges and summits with shallow, poorly developed soils, or fire histories). Subalpine areas are intermediate between alpine tundra and high elevation spruce – fir forest; they are distinguished by stunted spruce, fir and birch trees (krummholz) and a limited number of alpine species. These lower elevation areas are generally smaller and have communities with fewer alpine-restricted species. We recognize three primary systems for alpine and subalpine vegetation, corresponding to our high alpine peaks, lower subalpine ridges and summits, and wet alpine ravines.

• Alpine tundra system

Landscape settings: exposed summits and ridges

Soils: shallow, mostly very acidic, well drained organic and/or coarse mineral material (sand, gravel, stone) over bedrock; patterned frost-action features are evident in places (rock rings, rock stripes, soil boils, and stone terraces resulting from differential movement of coarse and fine mineral material); also open talus and felsenmeer

Spatial pattern: small to large patches (5 – 1000+), irregular zonation; patterned frost-action features evident within some communities

Physiognomy: sparsely vegetated, dwarf shrubland, and herbaceous vegetation with scattered krummholz (stunted trees < two meters tall)

Distribution: White Mountains

Description: The primary system in the alpine zone is the alpine tundra system, which is restricted to the higher peaks of the White Mountains. This system is dominated by classic ***sedge – rush – heath meadows***, ***felsenmeer***, and other well drained natural communities that occupy most of the summits, ridges and slopes above treeline (e.g., above 4900 ft. and down to about 4200 ft. on exposed ridges of a few higher peaks). It contrasts with alpine ravine/snowbank systems, which occur in the steep, wet, and snow-laden environments of our large, high-elevation ravines. Both of these systems contrast with the

subalpine heath - krummholz/rocky bald system found on summits and ridges from 3000 - 4900 ft. *Alpine/subalpine bog systems* occur as relatively small but distinct peatland patches in some alpine and subalpine areas.

The five diagnostic natural communities below comprise a high percentage of the area in the alpine tundra system. Within this mosaic smaller patches of several other communities are found. ***Black spruce/balsam fir krummholz*** is common as a narrow band at the transition to spruce - fir forest and also occurs as small island patches above treeline. Small patches of ***alpine herbaceous snowbank/rill*** and ***alpine cliff*** communities are also found in the mosaic, but the largest patches of these communities occur in alpine ravine/snowbank systems in Tuckerman Ravine, Oakes Gulf, and Great Gulf.

There are about 70 species largely restricted to the alpine zones of the White Mountains. The dominant plants of this system include dwarf alpine shrubs (bilberry, cranberry, and blueberry heaths, other dwarf shrubs), alpine sedges and rushes, and relatively few forbs. Nearly all of these plants are perennials. The alpine restricted species found in the alpine tundra (examples listed below) are absent or in much-reduced abundance on lower subalpine heath – krummholz/rocky bald systems. Endemic or near-endemic species of alpine areas of northeastern North America include *Prenanthes boottii* (Boott's rattlesnake-root)*, *Potentilla robbinsiana* (dwarf cinquefoil)*, and *Geum peckii* (mountain avens)*.

In New Hampshire, alpine tundra systems are restricted to the Presidential Range (from Mt. Madison to Mt. Pierce), Franconia Ridge, and smaller but nonetheless substantial patches on Mt. Moosilauke, Mt. Guyot, Bondcliff, and (arguably) on South Twin Mtn.

Diagnostic natural communities:

- Diapensia shrubland (S1)
- Alpine heath snowbank (S1S2)
- Bigelow's sedge meadow (S1)
- Sedge - rush - heath meadow (S1)
- Felsenmeer (S2)

Occasional or peripheral natural communities:

- Black spruce/balsam fir krummholz (S2S3)
- Labrador tea heath - krummholz (S2)
- Montane landslide (S3S4)
- Alpine herbaceous snowbank/rill (S1)
- Moist alpine herb - heath meadow (S1)
- Alpine cliff (S2)

Associated natural community systems: The alpine tundra system occasionally transitions at lower elevations to subalpine heath – krummholz/rocky bald systems but more often directly to high-elevation spruce – fir forest. Alpine/subalpine bog systems are most commonly associated with subalpine heath – krummholz/rocky bald systems at slightly lower elevations, but a few occurrences are embedded in the higher elevation alpine tundra system of the Presidential Range.

Characteristic species:

Species largely restricted to the alpine tundra system:

Herbs

Carex bigelowii (Bigelow's sedge)*

Juncus trifidus (highland rush)

Hierochloe alpina (alpine sweet grass)*

Geum peckii (mountain avens)* - near endemic

Prenanthes boottii (Boott's rattlesnake-root)* - northeastern endemic

Potentilla robbinsiana (dwarf cinquefoil)* - endemic

Dwarf shrubs

Diapensia lapponica (diapensia)*

Salix uva-ursi (bearberry willow)*

Betula glandulosa (dwarf birch)*

Betula minor (small birch)*

Loiseleuria procumbens (alpine azalea)*

Rhododendron lapponicum (Lapland rosebay)*

Phyllodoce caerulea (mountain-heath)*

• Alpine ravine/snowbank system

Landscape settings: high-elevation ravines, particularly those with distinct cirque headwalls

Soils: dry to wet, mostly acidic, somewhat poorly- to well-drained, shallow organic or organic-rich coarse mineral materials over rock; also bare talus and bedrock (outcrops, slabs, and cliffs); mixed mineral debris in landslide gullies and debris cones

Spatial pattern: small to large patch (50 – 300+ acres), irregular and vertical-linear zonation

Physiognomy: sparsely vegetated, dwarf shrubland, herbaceous, krummholz, and tall shrub thicket

Distribution: Presidential Range of the White Mountains

Description: Alpine ravine/snowbank systems are distinguished from alpine tundra systems by the unique convergence of several natural communities that occur in high alpine ravines. Alpine ravines have the largest occurrences and/or concentration of ***alpine herbaceous snowbank/rill***, ***alpine cliff***, ***alpine ravine shrub thicket***, ***black spruce/balsam fir krummholz***, and ***montane landslide*** natural communities. This system is most distinct in the major, high-elevation, cirque-like ravines with large snowpacks on the eastern side of the Presidential Range (Oakes Gulf, Tuckerman Ravine, Huntington Ravine, and Great Gulf). These ravines have a classic bowl-shaped cirque headwall rimmed by alpine cliffs and rock slabs, divided by landslide and avalanche gullies with alpine rill streams or choked with talus. ***High-elevation balsam fir forest*** extends up from the ravine bottom and onto the ravine side-slopes, becoming shorter and scrubbier as it transitions to krummholz, heath - krummholz, or other alpine/subalpine communities. A few ravines have ***subalpine cold-air talus barrens*** at their base where late-melting ice under huge boulders supports stunted *Picea mariana* (black spruce) and alpine plants well below treeline. ***Alpine herbaceous snowbank/rill*** communities are found along steep and wet rocky gullies, at the bases of headwalls, and on the wet brows of the ravine above the headwall. Alpine ravine systems are less distinct in smaller and lower elevation ravines that have a higher proportion of ***black spruce/balsam fir krummholz*** and scrubby ***high-elevation balsam fir forest*** and smaller patches of the other diagnostic communities.

Species listed below are specific to snowbank, rill, ravine, or cliff habitats and thus are more frequent or abundant in this system than in the more well drained conditions of the alpine tundra system, although some are found in smaller isolated snowbank patches or along rills outside of ravine settings.

Diagnostic natural communities:

- Alpine herbaceous snowbank/rill (S1)
- Alpine ravine shrub thicket (S1S2)
- Black spruce/balsam fir krummholz (S2S3)
- Montane landslide (S3S4)
- Alpine cliff (S2)
- Alpine heath snowbank (S1S2)
- Subalpine cold-air talus barren (S1)

Peripheral or occasional natural communities:

- Labrador tea heath – krummholz (S2)
- Subalpine sliding fen (S1)
- Moist alpine herb – heath meadow (S1)
- Sedge – rush – heath meadow (S1)

Associated natural community systems: This system transitions to alpine tundra on more well drained slopes and ridges above alpine ravines, and to high-elevation spruce – fir forest systems at lower elevations.

Characteristic species:

Plants abundant and concentrated in alpine ravine/snowbank systems
(snowbank, rill, ravine, and cliff habitats):

Shrubs

Alnus viridis var. *crispa* (mountain alder)
Vaccinium cespitosum (dwarf bilberry)
Salix argyrocarpa (silver willow)*
Salix planifolia (tea-leaved willow)*
Spiraea septentrionalis (alpine meadow-sweet)*

Herbs

Solidago macrophylla (large-leaved goldenrod)
Veratrum viride (false hellebore)
Viola palustris (alpine marsh violet)*
Arnica lanceolata (arnica)*
Oxyria digyna (mountain sorrel)*
Epilobium hornemannii (Hornemann's willow-herb)*
Sibbaldia procumbens (sibbaldia)*
Saxifraga rivularis (alpine brook saxifrage)*
Saxifraga cernua (nodding saxifrage)*
Saxifraga aizoon var. *neogaea* (livelong saxifrage)*

• Subalpine heath - krummholz/rocky bald system

Landscape settings: exposed summits and ridges

Soils: dry to moist, mostly very acidic, well drained, shallow organic and/or coarse mineral soils (sand, gravel) over bedrock or talus, with frequent rock outcrop exposures

Spatial pattern: small to large patch (<5 – 200+ acres), irregular zonation

Physiognomy: sparsely vegetated to dwarf shrubland structure with patches of krummholz (stunted trees < two meters tall)

Distribution: White Mountains and high elevations to the south from about 3000 to 4900 ft. elevation

Description: This system occurs on summits and ridges from about 3000 ft. to 4900 ft. outside the Presidential Range and Franconia Ridge. It is characterized by one or, less frequently, both of the two heath – krummholz communities and sometimes ***dwarf shrub – bilberry – rush barrens*** in more exposed areas. A few peaks have extensive, sparsely-vegetated bedrock exposures classified as ***subalpine rocky balds***.

The two heath – krummholz communities that are diagnostic of this system contain bilberry, cranberry, and blueberry heaths joined by various mixtures of *Ledum groenlandicum* (Labrador-tea) and *Kalmia angustifolia* (sheep laurel). The lichens are common and often abundant. Heath - krummholz communities occur as nearly pure dwarf shrublands (<10-15 cm tall) to mixtures of 20-60% krummholz. Heath – krummholz usually has substantial rock, talus, gravel, or stone exposure (>25%). *Picea rubens* (red spruce) is among the krummholz-forming trees below 3500 ft., and *Picea mariana* (black spruce) appears above 3500 ft. *Betula cordifolia* (heartleaf birch) and *Abies balsamea* (balsam fir) are found throughout. ***Sheep laurel – Labrador tea heath – krummholz*** occurs on peaks between 3000 and 3500 ft.; above this, sheep laurel, red spruce and other species drop out, marking the transition to ***Labrador tea heath – krummholz***. Typically either one or the other of these heath - krummholz communities is present, probably due to the restricted elevation range of the subalpine area on any given peak.

More exposed areas of this system on rocky or gravelly substrate correspond to ***dwarf shrub – bilberry – rush barren*** (above 3400 ft.) or ***subalpine rocky bald*** (mostly < 3500 ft.) communities. Floristically, the ***dwarf shrub – bilberry –rush barren*** is intermediate between heath – krummholz and ***sedge – rush – heath*** communities; it lacks the abundance of *Kalmia angustifolia* (sheep laurel), *Ledum groenlandicum* (Labrador-tea), and krummholz patches found in heath – krummholz communities *and* has a lower abundance of *Carex bigelowii* (Bigelow's sedge)* and *Juncus trifidus* (highland rush) than found in the ***sedge – rush – heath*** community of higher elevations. It is essentially a subalpine analogue to ***sedge – rush – heath meadow*** and ***diapensia shrubland*** communities that occurs in exposed settings with shallow or ephemeral snow cover. Vegetation is typically dwarfed (less than 20 cm in height) and dominated by crowberries, subalpine *Vaccinium* species, and *Potentilla tridentata* (three-toothed cinquefoil). Higher elevation alpine tundra and alpine ravine/snowbank species are absent or intermittent in this system (see list under alpine tundra system).

Diagnostic natural communities:

- Dwarf shrub - bilberry - rush barren (S2)
- Black spruce/balsam fir krummholz (S2S3)
- Labrador tea heath - krummholz (S2)
- Sheep laurel - Labrador tea heath - krummholz (S2)
- Subalpine rocky bald (S2)

Peripheral or occasional natural communities:

- Diapensia shrubland (S1)
- Red spruce - heath - cinquefoil rocky ridge (S3S4)
- Montane heath woodland (S2)

Associated natural community systems: Most examples of this system occur at the tops of higher peaks outside of the Presidential Range and Franconia Ridge, and therefore do not transition to alpine tundra systems. At lower elevations this system does often transition to montane rocky ridge systems or high-elevation spruce – fir forest. In parts of the White Mountains, this system forms mosaics with alpine/subalpine bogs that have collectively been referred to as "heath balds" (Fahey 1976; Doyle 1987). These "heath balds" occur mostly below 4000 ft. elevation on flat to gently sloping ridgetops of the Mahoosuc, Carter-Moriah, and Baldface Ranges, with a few smaller examples found in several other scattered locations.

Characteristic species:

Species characteristic of both heath – krummholz communities:

Krummholz trees (<2 m height)

Betula cordifolia (heartleaf birch)
Abies balsamea (balsam fir)

Shrubs

Ledum groenlandicum (Labrador-tea)
Vaccinium uliginosum (alpine bilberry)
Vaccinium vitis-idaea (mountain cranberry)
Vaccinium angustifolium (late low blueberry)
Vaccinium myrtilloides (velvet-leaved blueberry)
Empetrum nigrum (black crowberry)
Empetrum atropurpureum (purple crowberry)

Lichens

Cladina rangiferina
Cladina alpestris
Cetraria islandica

Species restricted to sheep laurel type:

Picea rubens (red spruce)
Kalmia angustifolia (sheep laurel)
Rhododendron canadense (rhodora)
Nemopanthus mucronatus (mountain holly)

Species restricted to Labrador tea type:

Picea mariana (black spruce)

Dwarf shrub – bilberry – rush barren:

Shrubs
Vaccinium uliginosum (alpine bilberry)
Vaccinium vitis-idaea (mountain cranberry)
Vaccinium angustifolium (late low blueberry)
Potentilla tridentata (three-toothed cinquefoil)
Empetrum nigrum (black crowberry)
Empetrum atropurpureum (purple crowberry)
Ledum groenlandicum (Labrador tea)
Diapensia lapponica (diapensia)* (>3500 ft.)

Herbs
Occasional species:
Carex bigelowii (Bigelow's sedge)*
Juncus trifidus (highland rush)
Solidago cutleri (Cutler's goldenrod)*

Lichens
Cladina rangiferina
Cetraria islandica

Subalpine rocky bald:

Shrubs
Rhododendron canadense (rhodora)
Nemopanthus mucronatus (mountain holly)
Kalmia angustifolia (sheep laurel)
Vaccinium uliginosum (alpine bilberry)
Vaccinium vitis-idaea (mountain cranberry)
Vaccinium angustifolium (late low blueberry)
Potentilla tridentata (three-toothed cinquefoil)
Empetrum nigrum (black crowberry)
Empetrum atropurpureum (purple crowberry)
Ledum groenlandicum (Labrador tea)

Herbs
Minuartia groenlandica (mountain sandwort)
Juncus trifidus (highland rush)

Lichens
Cladina rangiferina
Cetraria islandica

CLIFFS

For pragmatic purposes, cliffs are defined as greater than three meters in height and 65 degrees slope. Lower-angle bedrock exposures are referred to as slabs and are treated in this classification as steep versions of rocky ridge communities. There is considerable variation in cliff vegetation that relates to the wide range of conditions found among and within cliffs in New Hampshire, including latitude, elevation, moisture regime, degree of fracturing (e.g., highly-fractured vs. "massive" bedrock), pH, and base-cation status. In fact, it is not uncommon to see much of this variation within a single cliff; other cliffs are fairly uniform and homogenous with, for instance, only dry, acidic conditions and more northern plants throughout. While this variation is considerable, the most consistent theme among cliffs appears to be that the communities and plants present typically reflect the climatic regime of the site. Thus, we classify cliff systems into two broad types: montane cliff system and temperate cliff system. Examples within each type do exhibit some variation in terms of community composition and dominance, but usually the vegetation is reflective of one or the other climatic regions.

• Montane cliff system

Landscape settings: steep outcrops on hill side slopes

Soils: dry to wet, acidic to circumneutral, turfy mineral to organic substrates in cracks and on benches

Spatial pattern: steep outcrops (in excess of 65 degrees slope) to over-hanging (<1 – 100+ acres); irregular

Physiognomy: sparsely vegetated to partially wooded

Distribution: mostly above 1000 ft. elevation in the White Mountains and northward, and scattered in adjacent subsections to the south

Description: Montane cliffs in NH are generally found above 1000 ft. in elevation (mostly > 1200 ft.) and are thus concentrated in the White Mountain region and sparingly at higher elevations in the Sunapee Uplands and Sebago-Ossipee Hills and Plains subsections of central NH. Cliffs from around 900-1200 ft. elevation along the low elevation valleys of the White Mountains are transitional to temperate cliff systems. The most common natural community in this system is ***montane acidic cliff***, which dominates the entire area of many cliffs. ***Montane circumneutral cliff*** communities are relatively uncommon within this system, and when they do occur they are often restricted to only certain zones of a cliff, with the remainder of the cliff corresponding to ***montane acidic cliff***. A few large montane cliffs (e.g., Cannon Cliff) have ***alpine cliff*** communities, but most alpine cliffs are found as part of the complex community mosaic in alpine ravine/snowbank systems.

Circumneutral cliffs are associated with at least two circumstances: 1) where the matrix bedrock is intermediate, mafic, calc-silicate, or carbonate-bearing; and/or 2) where fractured-rock groundwater (particularly under overhangs) transports base-cations to the cliff face. Many cliffs have both acidic and circumneutral zones that result from substantial small-scale variation in fractured-rock groundwater inputs of base-rich water (Bailey 2001, Sperduto 2001, Sperduto 2002). Thus, the circumneutral portion of the cliff varies from very small, restricted areas (e.g., tens of square feet) to more extensive (e.g.,

acres). Only a few cliffs in New Hampshire have close to uniformly circumneutral conditions across the entire cliff face. Bryophytes are excellent and sensitive indicators of pH conditions.

Cliff seep communities are also relatively common in montane cliff systems. Typically they occupy relatively small areas but occasionally cover an acre or more in extent. The plants that occur on cliff seeps are very distinct from those that typify more dry or mesic cliff conditions; the difference is equivalent to that seen when going from a fen to an upland forest. They range from acidic to circumneutral conditions and are indicated by wetland species.

Diagnostic natural communities:

- Montane acidic cliff (S5)
- Montane circumneutral cliff (S2S3)
- Cliff seep (S3S4)

Peripheral or occasional natural communities:

- Red spruce - heath - cinquefoil rocky ridge (S3S4) – on slab portions of cliff system
- Circumneutral rocky ridge (S1)
- Alpine cliff (S2)

Associated natural community systems: Cliff systems are often but not always associated with talus systems; massive cliffs with little fracturing tend not to have much talus debris at their bases, whereas those with considerable fracturing do have talus slopes. Montane cliffs are also frequently associated with montane rocky ridge and slab systems and subalpine heath - krummholz/rocky bald systems.

Characteristic species:

Montane acidic cliff:

Picea rubens (red spruce)
Abies balsamea (balsam fir)
Potentilla tridentata (three-toothed cinquefoil)
Juncus trifidus (highland rush)
Paronychia argyrocoma var. *albimontana* (silverling)*
Aster acuminatus (whorled aster)
Betula alleghaniensis (yellow birch)

On both montane and lowland acidic cliffs:

Deschampsia flexuosa (common hair-grass)
Polypodium virginianum (rock polypody)
Cystopteris tenuis (Mackay's brittle fern)
Cystopteris fragilis (fragile fern)

Montane circumneutral cliff:

Vascular plants
Campanula rotundifolia (harebell)
Dryopteris fragrans (fragrant fern)*
Potentilla floribunda (shrubby cinquefoil)
Thuja occidentalis (northern white cedar)
Woodsia ilvensis (rusty woodsia)

Bryophytes
Tortella tortuosa (moss)*
Gymnostomum aeruginosum (moss)*
Distichium capillaceum (moss)*
Myurella siberica (liverwort)*
Amphidium mougeotii (moss)*

On both montane and lowland circumneutral cliffs:

Asplenium trichomanes (maidenhair spleenwort)*
Woodsia ilvensis (rusty woodsia)
Sambucus racemosa ssp. *pubens* (red elderberry)

Cliff seep:

Acid seepage indicators:
Drosera rotundifolia (round-leaved sundew)
Houstonia caerulea (bluets)
Viola spp. (violets)
Circaea alpina (small enchanter's nightshade)

Subacid to circumneutral seepage indicators:
Vascular plants
Scirpus hudsonianus (northern cotton club rush)
Pinguicula vulgaris (common butterwort)*
Woodsia glabella (smooth woodsia)*

Bryophytes
Preissia quadrata (liverwort)*
Mnium thomsonii (moss)*
Cryptomnium hymenophylloides (moss)*
Conocephalum conicum (liverwort)

• Temperate cliff system

Landscape settings: steep outcrops on hill side slopes

Soils: dry to wet, acidic to circumneutral, turfy mineral to organic substrates in cracks and on benches

Spatial pattern: steep outcrops (in excess of 65 degrees slope) to over-hanging (<1 – 5+ acres); irregular

Physiognomy: sparsely vegetated to partially wooded

Distribution: mostly below 1000 ft. elevation south of the White Mountains

Description: Temperate cliffs in NH are generally found below 1000 ft. in elevation and thus are concentrated in the lowland areas of central and southern NH south of the White Mountain region. A few cliffs up to about 1200 ft. elevation in the low elevation valleys of the White Mountains are transitional to montane cliff systems and have characteristics of both. The most common natural community in this system is the ***lowland acidic cliff*** community, which dominates the entire area of many cliffs. ***Lowland circumneutral cliff*** communities are relatively rare within this system, but when they do occur they can be restricted to a small portion of a cliff, with the remainder of the cliff classified as a ***lowland acidic cliff***.

Circumneutral cliffs are associated with at least two circumstances: 1) where the matrix bedrock is intermediate, mafic, calc-silicate, or carbonate-bearing; and/or 2) where fractured rock groundwater (particularly under overhangs) transports base-cations to the cliff face. Many cliffs have both acidic and circumneutral zones that result from substantial small-scale variation in fractured rock groundwater inputs of base-rich water (Bailey 2001, Sperduto 2001, Sperduto 2002). Thus, the circumneutral portion of the cliff varies from very small, restricted areas (e.g., tens of square feet) to more extensive (e.g., hundreds of square feet). Only a few cliffs in New Hampshire have uniformly circumneutral conditions across much of the cliff face.

Cliff seep communities are found on some in temperate cliff systems. They typically occupy a relatively small area in temperate cliffs systems (they are larger in some montane cliff systems). Cliff seeps are indicated by wetland plants, which contrast distinctly with plants indicative of dry to mesic conditions in other cliff habitats.

Montane and ***lowland acidic cliffs*** share numerous species. Those more common or abundant on ***lowland acidic cliffs*** include oaks, pines, eastern red cedar, and other southern species. However, it is often as much the absence of northern plants such as spruce and northern white cedar (see description above) as it is the presence of southern species that indicates a temperate cliff system.

Diagnostic natural communities:

- Lowland acidic cliff (S4)
- Lowland circumneutral cliff (S2)
- Cliff seep (S3S4)

Peripheral or occasional natural communities:

- Appalachian oak – pine rocky ridge (S3)

Associated natural community systems: Temperate cliff systems are often but not always associated with temperate talus systems; massive cliffs with little fracturing tend not to have much talus debris at their bases, whereas those with considerable fracturing tend to have more talus. Temperate cliffs are often associated with Appalachian oak rocky ridge systems.

Characteristic species:

Lowland acidic cliff:

Trees
Pinus strobus (white pine)
Quercus rubra (red oak)
Juniperus virginiana (eastern red cedar)

Herbs
Deschampsia flexuosa (common hair-grass)
Polypodium virginianum (rock polypody)
Cystopteris tenuis (Mackay's brittle fern)
Cystopteris fragilis (fragile fern)

Lowland circumneutral cliff:

Asplenium trichomanes (maidenhair spleenwort)*
Woodsia ilvensis (rusty woodsia)
Sambucus racemosa ssp. *pubens* (red elderberry)
Saxifraga virginiensis (early saxifrage)
Cornus rugosa (round-leaved dogwood)

Cliff seep:

Drosera rotundifolia (round-leaved sundew)
Houstonia caerulea (bluets)
Viola spp. (violets)
Circaea alpina (small enchanter's nightshade)

• Montane rocky ridge system

Landscape settings: outcrops and shallow-to-bedrock areas on ridges, summits, and steep side slopes

Soils: shallow, very acidic, organic and turfy mineral materials over bedrock

Spatial pattern: irregular and elliptically linear (along ridges) with frequent outcrops (<5 – 100+ acres); irregular zonation

Physiognomy: woodland and sparse woodlands with trees, short shrubs, and some herbs; sparsely vegetated outcrop openings are embedded at a finer scale

Distribution: mid-elevations (1300 – 3000 ft.) in western and northern NH, most abundant in the White Mountains

Description: Montane rocky ridges occur on outcrops and shallow-to-bedrock ridges and summits at mid-elevations in New Hampshire. They are dominated by some combination of *Picea rubens* (red spruce), *Pinus resinosa* (red pine), and *Quercus rubra* (red oak). Outcrops include cliff slabs, which are steep bedrock exposures of less than 65 degree slope. This system includes nearly all the rocky ridges in the White Mountain region and other rocky exposures between 1300 – 3000 ft. elevation elsewhere in the state. These rocky ridges, summits, and slabs have a woodland to sparse woodland canopy structure (ranging from completely open patches to thin forest cover > 65%), much open bedrock exposure, and one or more of the three primary diagnostic communities that overlap in their elevation ranges. ***Red oak – pine rocky ridges*** occur between 1000 – 1800 ft.; ***red pine rocky ridges*** between 900 – 2700 ft. (most are between 1400 – 2400); and ***red spruce – heath – cinquefoil rocky ridges*** from 1700 – 3000 ft. ***Jack pine rocky ridge woodland*** communities occur at a few sites in the White Mountains up to about 4000 ft. elevation. Many ridge, slab, and outcrop areas are characterized by two or sometimes all three of these diagnostic communities depending on the elevation range or other ecological influences present at the site. Although many specific locations on the ground correspond definitively to one of these communities, ambiguous transition areas are also common, where the three primary species mix in various combinations. Small cliffs are found in some examples of this system. In contrast with montane rocky ridge and slab systems, Appalachian oak rocky ridge systems occur at lower elevations away from the White Mtns (mostly <1000 ft., but occasionally to 1200 ft.) and have numerous southern species such as Appalachian oaks (white, black, scarlet, and scrub) and hickory and little or no red pine or red spruce.

Diagnostic natural communities:

- Red spruce - heath - cinquefoil rocky ridge (S3S4)
- Red pine rocky ridge (S2)
- Red oak - pine rocky ridge (S3S4)
- Jack pine rocky ridge woodland (S1)
- Montane heath woodland (S2)

Peripheral or occasional natural communities:

- Montane acidic cliff (S5)

Associated natural community systems: Downslope, this system sometimes transitions to montane cliff, montane acidic talus, or rich north-temperate talus/rocky slope systems. Upslope (when it exists), this system transitions to subalpine heath – krummholz/rocky bald, northern hardwood – conifer, or high-elevation spruce – fir – (northern hardwood) forest systems.

Characteristic species:

Trees

Picea rubens (red spruce)

Pinus resinosa (red pine)

Pinus banksiana (jack pine)

Quercus rubra (red oak)

Abies balsamea (balsam fir)

Betula cordifolia (heartleaf birch)

Sorbus americana (American mountain ash)

Sorbus decora (showy mountain ash)

Shrubs

Vaccinium myrtilloides (velvet-leaf blueberry)

Rhododendron canadense (rhodora)

Amelanchier bartramiana (Bartram's serviceberry)

Potentilla tridentata (three-toothed cinquefoil)

Herbs

Solidago randii (Rand's goldenrod)

Paronychia argyrocoma var. *albimontana* (silverling)*

Oryzopsis canadensis (Canadian rice-grass)*

Polygonum douglasii (Douglas' knotweed)*

Species common to both montane and Appalachian rocky ridges:

Vaccinium angustifolium (lowbush blueberry)

Deschampsia flexuosa (common hair-grass)

Betula papyrifera (paper birch)

Maianthemum canadense (Canada mayflower)

Kalmia angustifolia (sheep laurel)

Pteridium aquilinum var. *latiusculum* (bracken fern)

Gaultheria procumbens (wintergreen)

• Appalachian oak rocky ridge system

Landscape settings: outcrops and shallow-to-bedrock areas on ridges, summits, and steep side slopes

Soils: shallow, very acidic, organic and turfy mineral materials over bedrock

Spatial pattern: irregular and elliptically linear (along ridges) with frequent outcrops (<1 – 50+ acres); irregular zonation

Physiognomy: woodland and sparse woodlands with trees, short shrubs, and some herbs; sparsely vegetated outcrop openings are embedded at a finer scale

Distribution: below 1200 ft. in southern New Hampshire

Description: Appalachian oak rocky ridges occur on outcrops and shallow-to-bedrock ridge and summit settings at low elevations (below about 1200 ft.) in southern New Hampshire. They are dominated by southern oaks and pines with little if any *Picea rubens* (red spruce), *Pinus resinosa* (red pine), and other northern plants diagnostic of montane rocky ridge and slab systems. Outcrops include small cliff slabs, which are steep bedrock exposures of less than 65 degree slope. This system includes nearly all the rocky ridges in southern New Hampshire and most other ledges below 1000 ft. elevation. These ridges, summits, and slabs typically have a woodland to sparse woodland canopy (ranging from completely open patches to thin forest cover > 65%) and much open bedrock exposure.

Quercus rubra (red oak) is typically present as it is in montane rocky ridge and slabs, but the presence of other oaks is the key diagnostic feature of this system (in combination with the absence of red spruce and red pine and other northern plants in any abundance). Southern indicator species include *Quercus alba* (white oak), *Quercus velutina* (black oak), *Quercus prinus* (chestnut oak), *Quercus ilicifolia* (scrub oak), and occasionally hickories (*Carya* spp.). *Pinus strobus* (white pine) is common and *Pinus rigida* (pitch pine) and *Ostrya virginiana* (ironwood) are occasional.

Diagnostic natural communities:

- Appalachian oak - pine rocky ridge
- Chestnut oak forest/woodland (S1S2)

Peripheral or occasional natural communities:

- Dry Appalachian oak - hickory forest (S1S3)
- Red oak - ironwood - Pennsylvania sedge woodland (S2)
- Red oak - pine rocky ridge (S3S4)

Associated natural community systems: Rich Appalachian oak rocky woods are occasionally found below this system on mid- to lower-slope positions; otherwise this system typically transitions to adjacent oak – pine forest systems.

Characteristic species:

Appalachian oak – pine rocky ridge and ***chestnut oak forest/woodland***:

Trees

Quercus rubra (red oak)
Quercus alba (white oak)
Quercus velutina (black oak)
Quercus prinus (chestnut oak)
Quercus ilicifolia (scrub oak)
Carya spp. (hickories)
Pinus strobus (white pine)
Pinus rigida (pitch pine)
Ostrya virginiana (ironwood)

Shrubs

Vaccinium pallidum (hillside blueberry)
Gaylussacia baccata (black huckleberry)
Juniperus communis (ground juniper)
Comptonia peregrina (sweet fern)
Gaylussacia frondosa (dangleberry)
Arctostaphylos uva-ursi (bearberry)

Herbs

Aureolaria pedicularia var. *intercedens* (fern-leaved false-foxglove)*
Solidago odora (sweet goldenrod)*
Schizachyrium scoparium (little bluestem)

Species common to both montane and Appalachian oak rocky ridge systems:

Vaccinium angustifolium (lowbush blueberry)
Deschampsia flexuosa (common hair-grass)
Betula papyrifera (paper birch)
Maianthemum canadense (Canada mayflower)
Kalmia angustifolia (sheep laurel)
Pteridium aquilinum (bracken fern)
Gaultheria procumbens (wintergreen)

• Montane acidic talus system

Landscape settings: most common below cliffs on steep, mid- to lower-slope positions (concave or neutral slope); occasionally found in deep talus gorges or without a cliff

Soils: variable soils including no soil development on open talus; coarse to fine mineral colluvium accumulation among talus boulders or in gullies, often mixed with organic matter; with or without shallow organic layer development

Spatial pattern: small to large patches (<1 to 100's of acres); variable shaped but often somewhat linear-elliptical along base of cliff

Physiognomy: woodlands, sparse woodlands, and open talus with trees, herbs, shrubs, bryophytes, and/or lichens

Distribution: mid to high elevations in the White Mtns (mostly above 2200 feet, occasionally to 1500 ft.)

Description: Montane acidic talus slopes are found at mid to high elevations in the White Mountains and are characterized by spruce, fir, and various other northern species. This system tends to have an open woodland character, with frequent canopy gaps and lichen-dominated talus barren openings. Soil development is variable on these slopes, and moisture conditions range from dry to mesic. Larger examples have giant talus blocks at their base with late-melting ice that produces a cold, moist microclimate supporting alpine plants well below treeline. Most occurrences of this system are found above 2200 ft. elevation, but occasionally found down to about 1500 ft. This system includes a few lower elevation "talus gorges" such as Ice Gulch and Devil's Hopyard. Talus areas that are completely forested with no openings or woodland structure are likely to be better classified as a rocky example of a ***sugar maple – beech – yellow birch forest***, ***high-elevation spruce – fir forest***, or ***northern hardwood – spruce – fir forest*** natural communities.

The main community (***spruce – birch – mountain maple wooded talus***) in this system is partially wooded and has a patchy understory of shrubs, herbs, and sometimes dense carpets of bryophytes. ***Subalpine cold-air talus barrens*** correspond to talus areas with large, ice-cooled boulders where the microclimate supports black and red spruce, heaths and evergreen shrubs, and lichen and mosses characteristic of alpine and montane habitats. Mosses and lichens are abundant but not well documented to the species level. Herbaceous species are notably sparse or absent. Little is specifically documented about the biota in lichen talus barrens, but crustose, umbillicate, and foliose lichens are prominent.

Diagnostic natural communities:

- Spruce - birch - mountain maple wooded talus (S3)
- Subalpine cold-air talus barren (S1)
- Montane lichen talus barren (S3)
- Montane landslide (S3S4)

Peripheral or occasional natural communities:

- Alpine/subalpine pond (S1)

Associated natural community systems: Montane acidic talus slopes are often, but not always, found below montane cliff systems, and surrounded by either northern hardwood or high-elevation spruce – fir forest systems.

Characteristic species:

Spruce – birch – mountain maple wooded talus:

Trees and tall shrubs

Picea rubens (red spruce)
Abies balsamea (balsam fir)
Betula papyrifera var. *papyrifera* (paper birch)
Betula cordifolia (heartleaf birch)
Betula alleghaniensis (yellow birch)
Sorbus americana (American mountain ash)
Sorbus decora (showy mountain ash)
Acer spicatum (mountain maple)

Herbs, short shrubs, and vines

Polypodium virginianum (rock polypody)
Parthenocissus quinquefolia (Virginia creeper)
Polygonum cilinode (fringed bindweed)
Vaccinium angustifolium (lowbush blueberry)
Deschampsia flexuosa (common hair-grass)
Vaccinium myrtilloides (velvet-leaf blueberry)
Solidago randii (Rand's goldenrod)
Juncus trifidus (highland rush)
Ribes glandulosum (skunk currant)
*Vaccinium vitis-idaea (*mountain cranberry)
Clintonia borealis (blue-bead lily)

Subalpine cold-air talus barren:

Dwarf shrubs

Ledum groenlandicum (Labrador-tea)
Kalmia angustifolia (sheep laurel)
Empetrum nigrum (black crowberry)*
Empetrum atropurpureum (purple crowberry)*
Vaccinium vitis-idaea (mountain cranberry)
Vaccinium uliginosum (alpine bilberry)
Vaccinium myrtilloides (velvet-leaf blueberry)
Vaccinium angustifolium (early low blueberry)
Rhododendron canadense (rhodora)
Gaultheria hispidula (creeping snowberry)

Non-vascular

Mosses and liverworts abundant

Crustose, umbillicate, and foliose lichens abundant

• Temperate acidic talus system

Landscape settings: most common below cliffs on steep, mid- to lower-slope positions (concave or neutral slope); occasionally found without a cliff

Soils: variable soils including no soil development on open talus; coarse to fine mineral colluvium accumulation among talus boulders or in gullies, often mixed with organic matter; with or without shallow organic layer development

Spatial pattern: small patches (<1 to 10's of acres); variable shaped but often somewhat linear-elliptical along base of cliff

Physiognomy: woodlands, sparse woodlands, and open talus with trees, herbs, shrubs, bryophytes, and/or lichens

Distribution: low to mid elevations in southern and central New Hampshire (below 2200 ft.)

Description: Temperate acidic talus slopes are found at low elevations (below 1800 ft. elevation) in central and southern New Hampshire characterized by hardwoods including oaks (*Quercus* spp.) and *Betula lenta* (black birch), as well as other species indicative of a temperate climate. This system tends to have an open woodland character, with frequent canopy gaps and occasional lichen-dominated talus barren openings. Softwoods are generally sparse or absent. Shrubs, herbs and vines are the dominant understory plants; vines are more prevalent than in most till forests. Foliose, crustose, and umbillicate lichens are common on the talus rocks. Soil development is variable on these slopes, and moisture conditions range from dry to mesic. Most examples are smaller than montane acidic talus systems. A few temperate acidic talus slopes in the state have giant talus blocks with late-melting ice that produces a relatively cold, moist microclimate compared to the rest of the talus slope. These areas supports patches of montane species such as *Picea rubens* (red spruce) and *Sorbus americana* (American mountain ash) within the larger temperate mosaic. ***Red oak - hickory wooded talus*** in more southern and low elevation examples can have southern species such as *Quercus alba* (white oak), *Carya ovata* (shagbark hickory), and *Cornus florida* (flowering dogwood). Talus areas that are completely forested with no openings or woodland structure are likely to be better classified as a rocky example of ***hemlock – beech – oak – pine forest***.

Diagnostic natural communities:

- Red oak - black birch wooded talus (S3S4)
- Red oak - hickory wooded talus (S1S2)
- Temperate lichen talus barren (S2S3)

Associated natural community systems: This system transitions to forested talus or forested till areas characterized by hemlock – hardwood – pine forest or oak – pine forest systems. Temperate cliff systems are also often associated upslope and sometimes Appalachian oak rocky ridges.

Characteristic species:

Trees

Frequent trees:

Quercus rubra (red oak)

Betula lenta (black birch)

Fagus grandifolia (American beech)

Ostrya virginiana (ironwood)

Acer rubrum (red maple)

Acer spicatum (mountain maple)

Acer pensylvanicum (striped maple)

Betula alleghaniensis (yellow birch)

Occasional trees:

Acer saccharum (sugar maple)

Prunus pensylvanica (pin cherry)

Betula papyrifera (paper birch)

Betula populifolia (gray birch)

Shrubs and vines (lianas)

Hamamelis virginiana (witch hazel)

Rubus spp. (raspberries and blackberries)

Viburnum acerifolium (maple-leaved viburnum)

Ribes spp. (gooseberries and currents)

Sambucus racemosa (red-berried elder)

Polygonum cilinode (fringed bindweed)

Parthenocissus quinquefolia (Virginia creeper)

Parthenocissus vitacea (woodbine)

Toxicodendron radicans (climbing poison ivy)

Celastrus scandens (American bittersweet).

Herbs

Characteristic of talus slopes:

Smilacina racemosa (false Solomon's seal)

Dryopteris marginalis (marginal wood fern)

Polypodium virginianum (rock polypody).

Other common herbs:

Maianthemum canadense (Canada mayflower)

Aralia nudicaulis (wild sarsaparilla)

Trientalis borealis (starflower)

Lichens

Foliose, crustose, and umbillicate lichens are common

• Pitch pine sand plain system

Landscape settings: lowland, valley bottom settings with extensive sand and gravel deposits derived from glacio-fluvial meltwaters [outwash plains, ice-contact features (eskers, kames), and ancient river deltas and terraces]

Soils: Excessively well drained sands and gravels with modest duff accumulation due to frequent fire

Spatial pattern: small to large patches (10-1000 acres)

Physiognomy: woodlands with tall shrub, dwarf shrub, and graminoid dominated openings; successional to forest in the absence of fire

Distribution: central and southern NH

Description: This system occurs primarily on droughty, excessively well drained soils in central and southern New Hampshire and is most well developed on the extensive sand plain areas of the Ossipee and lower Merrimack Valley regions. These areas are characterized by a frequent historic fire regime and indicated by *Pinus rigida* (pitch pine), *Quercus ilicifolia* (scrub oak), other fire-maintained plant species, and numerous Lepidoptera that are obligates to these plants. The central natural community, ***pitch pine - scrub oak woodland***, forms a discontinuous canopy with dense shrub stratums of scrub oak and low heaths. Several successional and disturbance-related expressions can be present including scrub oak thickets, pockets of pitch pine forest, grassy openings, and heath barrens. Fire is important for maintaining community structure, dynamics, and composition (floristic and faunal). ***Pitch pine - scrub oak woodlands*** require fire return intervals of at most 50-100 years to maintain community composition. Logging history also influences canopy structure, and in combination with fire history, explains much of the compositional variation seen in this system. Other natural communities are characteristic in the larger mosaic, particularly in portions of the sand plain that have had less frequent fire return intervals (i.e., areas more isolated from the most frequently burned areas) or those that occur on somewhat more mesic sandy soils (i.e., those adjacent to rivers or wetlands).

Diagnostic natural communities:

- Pitch pine - scrub oak woodland (S1S2)

<u>Primarily found in the Ossipee region</u>

- Mixed pine - red oak woodland (S1)
- Red pine - white pine - balsam fir forest (S3)

<u>Primarily found in the Merrimack Valley and coastal regions</u>

- Pitch pine - Appalachian oak - heath forest (S1)

Peripheral or occasional natural communities:

- Dry red oak - white pine forest (S3S4)
- Dry Appalachian oak - hickory forest (S1S3)
- Dry riverbluff (S2?)

Associated natural community systems: This system is commonly punctuated by open peatland systems where sand plains intersect the water table. Kettle hole bog, poor level fen/bog, and medium level fen systems are most common in these landscapes. In central, NH pitch pine sand plain systems transition to hemlock - hardwood - pine forest system on adjacent sand plain or till settings with no (or a less frequent) fire history. In southern New Hampshire it transitions to Appalachian oak - pine forest systems on till or sand plain settings with less frequent fire histories.

Characteristic species:

Frequent species of the ***pitch pine - scrub oak woodland***:

Primarily sand plain species:

Pinus rigida (pitch pine)
Quercus ilicifolia (scrub oak)
Ceanothus americanus (eastern New Jersey tea)
Quercus prinoides (dwarf chestnut oak)*
Oryzopsis pungens (slender mountain rice-grass)
Lespedeza capitata (round headed bush-clover)
Leptoloma cognatum (fall witch-grass)
Lechea spp. (pinweeds)
Helianthemum canadense (Canadian frostweed)
Aster linariifolius (stiff-leaved aster)
Carex tonsa (shaved sedge)
Hudsonia ericoides (golden-heather)*
Liatris borealis (northern blazing star)*
Lupinus perennis (wild lupine)*
Asclepias amplexicaulis (blunt-leaved milkweed)*
Cyperus lupulinus (perennial umbrella-sedge)

Other common to occasional species:

Vaccinium angustifolium (lowbush blueberry)
Vaccinium pallidum (hillside blueberry)
Apocynum androsaemifolium (spreading dogbane)
Carex lucorum (distant sedge)
Comandra umbellata (bastard toad-flax)
Oryzopsis asperifolia (rough-leaved rice-grass)
Schizachyrium scoparium (little bluestem)
Pteridium aquilinum (bracken fern)
Comptonia peregrina (sweet fern)
Pinus strobus (white pine)
Betula populifolia (gray birch)
Quercus rubra (red oak)
Quercus velutina (black oak)

Frequent species of the ***mixed pine – red oak woodland***:

Trees

Pinus resinosa (red pine)
Pinus strobus (white pine)
Pinus rigida (pitch pine)
Quercus rubra (red oak)

Shrubs

Vaccinium angustifolium (lowbush blueberry)
Vaccinium pallidum (hillside blueberry)
Comptonia peregrina (sweet fern)
Quercus ilicifolia (scrub oak) – low abundance
Kalmia angustifolia (sheep laurel)

Herbs

Oryzopsis asperifolia (rough-leaved rice-grass)
Pteridium aquilinum (bracken fern)

• Coastal sand dune system

Landscape settings: coastal strands between ocean and estuarine or upland systems

Soils: shifting sands

Spatial pattern: small patch (1 - 20 acres); typically linear zones parallel to the shoreline with fore-dune and back-dune zones

Physiognomy: grassland, herbaceous, dwarf shrubland, shrubland, shrub thicket, forest/woodland

Distribution: limited to Seabrook

Description: Coastal dune systems correspond to areas with actively shifting sand associated with the immediate coastal environment. Several community types correspond to three broad zones: the foredune, the interdune, and the backdune. The two primary physical processes that produce these different zones and their corresponding communities are (1) the degree of exposure to or protection from on-shore winds and therefore degree of sand stabilization, and (2) soil moisture. The foredune is most exposed to onshore winds and salt spray and is typically dominated by *Ammophila breviligulata* (beach grass)* with few other species. The interdune is usually dominated by beach grass with a broader diversity of species. More protected portions of the dune (backdune) are characterized by maritime ("sunken") forests, shrub thickets, and interdunal swales. There is one partially intact dune system in New Hampshire (The Dunes in Seabrook) and several dune remnants elsewhere.

Beach grass grasslands are typically found on the foredune and other dune areas with shifting sand. In NH's only remaining example, most of the foredune has been destroyed by development. This community may also occur as a narrow strand of vegetation along the shore away from intact dune areas. *Ammophila breviligulata* (beach grass)*, the dominant species, creates extensive colonies by spreading underground rhizomes. Seaside goldenrod and beach heather can also be abundant. ***Bayberry - beach plum maritime shrublands*** are short to moderate height shrub thickets found in the backdune area and in small, protected hollows in the interdune. Sandy soils are a bit more stable than those found in the foredune and exposed areas of the interdune. ***Coastal interdunal marsh/swale*** is a freshwater wetland community found in sandy depressions between sand dunes. Dominants vary from swale to swale but include *Vaccinium macrocarpon* (large cranberry) and *Juncus arcticus* (shore rush). ***Coastal shoreline strand/swale*** is a sparsely vegetated upper intertidal community that can be found on backdune sandy depressions and channels bordering salt marshes. This community is flooded less than daily and is often characterized by plant stems and other detritus washed in on the higher tides and covering much of the substrate surface. These upper intertidal areas form either large patches or narrow strands along protected low-energy shorelines and are important habitat for various arthropods, shore birds, and other animals and are sparsely vegetated by halophytic herbs.

Diagnostic natural communities:

- Beach grass grassland (S1)
- Bayberry - beach plum maritime shrubland (S1)
- Coastal interdunal marsh/swale (S1)
- Maritime wooded dune (S1)

Peripheral or occasional natural communities:

- Coastal shoreline strand/swale (S2)

Associated natural community systems: Coastal sand dunes are typically sandwiched between salt marsh systems and open, wave-racked beaches on the immediate ocean shoreline.

Characteristic species:

Beach grass grassland:

Ammophila breviligulata (beach grass)*
Solidago sempervirens (seaside goldenrod)
Hudsonia tomentosa var. *tomentosa* (hairy hudsonia)*
Danthonia spicata (poverty oat-grass)
Schizachyrium scoparium (little bluestem)
Lathyrus japonicus (beach pea)
Lechea maritima (seabeach pinweed)
Polygonella articulata (jointweed)
Cyperus lupulinus (perennial umbrella-sedge)
Aristida tuberculosa (sea-beach needlegrass)*
Cyperus grayi (Gray's umbrella-sedge)*

Bayberry - beach plum maritime shrubland:

Shrubs
Myrica pensylvanica (northern bayberry)
Prunus maritima (beach plum)
Toxicodendron radicans (climbing poison ivy)
Rosa virginiana (Virginia rose)

Bayberry – beach plum (cont.):

Herbs
Oenothera perennis (small sundrops)
Achillea millefolium (yarrow)
Polygonum scandens (large climbing false buckwheat)
Artemisia campestris ssp. *caudata* (tall wormwood)*

Coastal interdunal marsh/swale:

Shrubs
Vaccinium macrocarpon (large cranberry)
Aronia prunifolia (purple chokeberry)
Ilex verticillata (winterberry)
Toxicodendron radicans (climbing poison ivy)

Herbs
Juncus arcticus (shore rush)
Triadenum virginicum (marsh St. John's-wort)

• Maritime rocky shore system

Landscape settings: offshore islands

Soils: Well to somewhat excessively well drained, thin soils over bedrock and in cracks in outcrop

Spatial pattern: small patch (<5 – 100+ acres); zonation parallel to shoreline

Physiognomy: shrub thickets, and sparsely vegetated rocky barrens and intertidal areas

Distribution: Isles of Shoals

Description: This system occurs on the Isles of Shoals off the New Hampshire coast. As small islands set miles off the coast into the Atlantic Ocean, they are considerably more exposed to and battered by the maritime environment than nearby mainland shore areas. Despite a long history of human use, these islands apparently retain some substantial areas of largely natural shrub thickets, rocky barrens, and intertidal areas exposed to and shaped by wave action, tides, heavy surf, salt spray, and when the tide is drawn down, dehydrating sun and wind. Early records indicate that these islands were probably never heavily wooded. The interior portions of the Isles of Shoals at one time may have been somewhat more wooded and corresponded to a mosaic of ***maritime shrub thicket*** and ***coastal rocky headland*** communities. The latter community has a woodland structure (25 – 65% tree cover) dominated by *Juniperus virginiana* (eastern red cedar) and *Myrica pensylvanica* (northern bayberry). This community is otherwise restricted to some rocky estuarine points in Great Bay. Based on an initial survey of Star Island, there are three apparently distinct natural communities that comprise the maritime rocky shore system: ***maritime shrub thicket***, ***maritime rocky barrens***, and ***maritime intertidal rocky shores***.

The ***maritime shrub thicket*** consists of short (mostly less than 1 m) to tall (mostly 1 – 2.5 m) shrub thickets found in interior areas away from the exposed rocky shorelines. These thickets are dominated by shrubs and stunted trees with a lower abundance of understory herbs. Prior to the island's long history of human land use, the maritime thicket likely covered most of the island.

Maritime rocky barrens lie between ***maritime shrub thickets*** at higher elevations and ***maritime intertidal rocky shores*** at lower elevations. These exposed rocky barrens have a sparse cover of herbs and even fewer shrubs that creep down from the shrub thicket above into protected crevices. Little soil and wind-driven salt spray limit plant growth on the exposed bedrock. Characteristic species include *Solidago sempervirens* (seaside goldenrod), *Juncus gerardii* (salt marsh rush), *Festuca rubra* (red fescue), *Aster subulatus* (small salt marsh aster), *Achillea millefolium* (European yarrow), *Toxicodendron radicans* (climbing poison ivy), and *Myrica pensylvanica* (northern bayberry). Several other associated species occur with a very sparse cover. A few small depressions within this community hold fresh to brackish water pools. Fresh water species include *Lemna minor* (lesser duckweed), *Polygonum hydropiper* (water-pepper), *Polygonum punctatum* (dotted smartweed), *Scutellaria galericulata* (marsh skullcap), *Iris versicolor* (northern blue flag), *Lycopus uniflorus* (common water horehound), and *Typha latifolia* (common cattail). Brackish water species are *Scirpus pungens* (three-square rush), *Scirpus robustus* (stout bulrush), *Eleocharis halophila* (salt-loving spike-rush), *Potentilla egedii* (coastal silverweed), *Lythrum hyssopifolia* (hyssop-leaved loosestrife), and *Juncus gerardii* (salt marsh rush).

Maritime intertidal rocky shores are found from the supra-littoral (splash) zone down to the shore expose at low tide. They are exposed to wave action, tides, and when the tides are drawn down, sun and wind.

These environmental factors have a strong influence on species composition and zonation. Vascular plant species are absent. Non-vascular species include blue-green algae and lichens in the supra-littoral and high littoral zones and several species of macroalgae in the middle and lower intertidal zones.

Diagnostic natural communities:

- Maritime shrub thicket (S1) (new community)
- Maritime rocky barren (S1) (new community)
- Maritime intertidal rocky shore (S1) (provisional type)
- Coastal shoreline strand/swale (S2)

Peripheral or occasional natural communities:

- Short graminoid – forb emergent marsh/mud flat
- Highbush blueberry – winterberry shrub thicket
- Coastal rocky headland (S1)

Associated natural community systems: This system occurs by itself on the Isles of Shoals.

Characteristic species:

Maritime shrub thicket:

Short and tall shrub thickets:

Abundant shrubs
Myrica pensylvanica (bayberry)
Aronia arbutifolia (red chokeberry)
Aronia melanocarpa (black chokeberry)
Toxicodendron radicans (poison ivy)
Rosa virginiana (low rose)
Amelanchier stolonifera (dwarf shadbush)

Other occasional species
Achillea millefolium (yarrow)
Festuca rubra (red fescue)
Aster novi-belgii (New York aster)
Sedum sp. (stonecrops)
Potentilla tridentata (three-toothed cinquefoil)
Agrostis capillaris (Rhode Island bent-grass)
Polygonum scandens (false buckwheat)
Prunus maritima (beach plum)

Tall shrub thickets (additional species):

Shrubs

Amelanchier canadensis (eastern shadbush)
Parthenocissus quinquefolia (Virginia creeper)
Rosa rugosa (rugose rose)
Rubus allegheniensis (common blackberry)
Rubus idaeus (red raspberry)
Prunus serotina (black cherry)
Acer rubrum (red maple)
Ilex verticillata (winterberry) – dom. in low wet swales

Herbs

Agrostis capillaris (Rhode Island bent-grass)
Anthoxanthum odoratum (sweet vernal grass)
Elytrigia repens (quack-grass)
Poa pratensis (Kentucky bluegrass)
Poa compressa (Canada bluegrass)
Fragaria virginiana (wild strawberry)
Smilacina stellata (starry Solomon's seal).

Maritime rocky barren:

Herbs

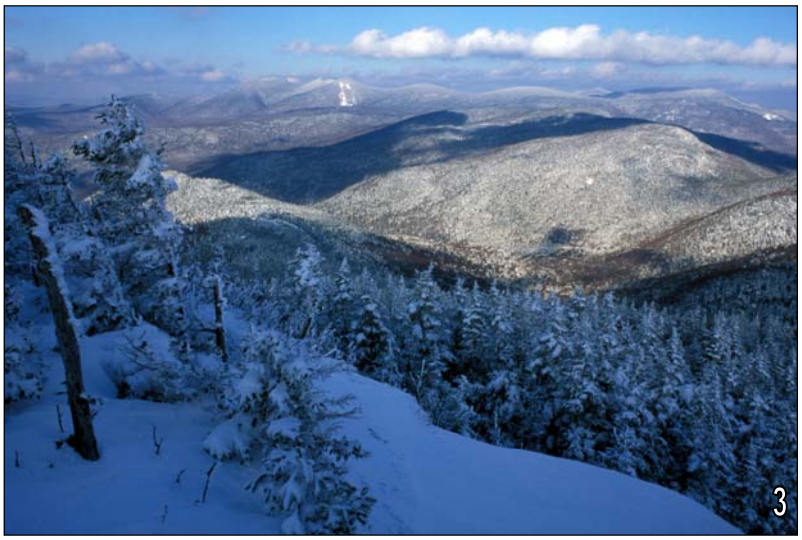
Solidago sempervirens (seaside goldenrod)
Juncus gerardii (salt marsh rush)
Festuca rubra (red fescue)
Aster subulatus (small salt marsh aster)
Achillea millefolium (European yarrow)
Toxicodendron radicans (climbing poison ivy)

Dwarf shrubs

Myrica pensylvanica (northern bayberry).

Small embedded fresh to brackish water depressions:

Lemna minor (lesser duckweed)
Polygonum hydropiper (water-pepper)
Polygonum punctatum (dotted smartweed)
Scutellaria galericulata (marsh skullcap)
Iris versicolor (northern blue flag)
Lycopus uniflorus (common water horehound)
Typha latifolia (common cattail)
Scirpus pungens (three-square rush)
Scirpus robustus (stout bulrush)
Eleocharis halophila (salt-loving spike-rush)
Potentilla egedii (coastal silverweed)
Lythrum hyssopifolia (hyssop-leaved loosestrife)
Juncus gerardii (salt marsh rush)



Forest systems, clockwise from top left:

1. ***Hemlock forest*** in hemlock – hardwood – pine forest system. Pawtuckaway State Park. Photo BDK.
2. ***Sugar maple – beech – yellow birch forest*** in northern hardwood – conifer forest system. Lafayette Brook, Franconia. Photo BDK.
3. ***High-elevation balsam fir forest*** community within high-elevation spruce-fir forest system. Jennings Peak, Waterville Valley. Photo DDS.
4. ***Northern hardwood – spruce – fir forest*** within northern hardwood – conifer forest system. Rattle River, Shelburne. Photo DDS.
5. ***Rich mesic forest*** inclusion within rich Appalachian oak rocky woods system. Pawtuckaway State Park. Photo DDS.
6. ***Semi-rich mesic forest*** community within northern hardwood – conifer system. Big Bickford Mtn., Franconia. Photo DDS.

PRIMARILY FOREST AND WOODLAND SYSTEMS ON TILL, FLUVIAL, TALUS, OR ROCKY SUBSTRATES

RICH HARDWOOD FORESTS ON TILL, ROCKY, OR TERRACE SUBSTRATES

Forests referred to as rich woods, rich mesic forests, or enriched hardwood forests are a distinct and consistent feature among hardwood forests throughout eastern North America. The terms "rich" and "enriched" are often used in a loosely defined manner, but typically in reference to presumed mineral or plant-nutrient levels of a site being greater than that of the dominant forests of the region, which are indicated by a suite of species restricted to these conditions. The degree of enrichment in forests is a function of a complex suite of interacting factors including: mineral composition of bedrock and till; rock weatherability; topographic position (including colluviation); hydrologic flow through soil and fractured bedrock that transports minerals; moisture status; other soil characteristics such as base saturation, texture, and organic matter content; and biological interactions (litter quality, soil and rock mychorrizae). Generally, rich hardwood forest soils appear to have higher base-saturation, calcium, and nitrogen availability levels than other forest types.

• Rich mesic forest system

Landscape settings: concave to neutral hillside slope positions, particularly in regions of calcium-rich bedrock and in topographic positions influenced by colluviation (e.g., slope-bases, below cliffs, and in coves and drainages)

Soils: variable: mesic to wet-mesic; well to moderately well drained; deep to shallow; loams, silt loams, and fine sandy loams with variable gravel and stone content; often with a well-mixed "mull" A horizon

Spatial pattern: variable (<1 – 20+ acres), although often elliptical or broad-linear when controlled by topographic features (i.e., slope-bases, coves, and drainages)

Physiognomy: forest

Distribution: throughout the state; more common in regions dominated by calcium-rich bedrock

Description: Rich mesic forest systems are relatively small but unique forest areas that, despite some minor herbaceous variation, exhibit a remarkably consistent composition from northern to southern New Hampshire. This is in contrast to the matrix forest types surrounding the rich mesic forests, which range from northern hardwood (-conifer) forests in northern New Hampshire, to hemlock - hardwood - pine or Appalachian oak - pine forest systems further south. In all cases, this forest system is marked by the dominance of sugar maple and a host of rich-site indicator species largely restricted to enriched hardwood forests. *Fagus grandifolia* (American beech) and *Betula alleghaniensis* (yellow birch) are more abundant in semi-rich areas and less frequent in rich mesic forests. While rocky areas can be present, this system contrasts with rich north-temperate talus/rocky woods and rich Appalachian oak rocky woods systems by the absence of extensive talus or loose rocky slopes with herbs and species preferential to dry-mesic rocky sites. They are most common and largest in areas with relatively calcium-rich bedrock and in association with slope-bases and coves, and on river terrace escarpments along the Connecticut and Merrimack Rivers. This system more often than not has a mix of ***rich mesic forest*** and ***semi-rich mesic sugar maple***

forest communities. On river terrace slopes and adjacent terrace flats, rich mesic forest systems can include the ***rich sugar maple – oak – hickory forest*** community.

Rich mesic forests are indicated by a large number of rich and semi-rich site indicators, many of which are "vernal herbs" that flower and fruit early in the season before tree canopies have fully emerged. There are numerous other herbs that occur in rich mesic forests not listed below, including those found in more nutrient-poor matrix forests of the region.

Diagnostic natural communities:

- Rich mesic forest (S3)
- Semi-rich mesic sugar maple forest (S3S4)
- Rich sugar maple – oak – hickory terrace forest (S1)

Peripheral or occasional natural communities:

- Semi-rich Appalachian oak - sugar maple forest (S2S3)

Associated natural community systems: Rich mesic forest systems are found as small to large patches in northern hardwood – conifer forest, hemlock – hardwood – pine forest, and less frequently Appalachian oak – pine forest systems.

Characteristic species:

Semi-rich mesic sugar maple forest:

Trees and shrubs
Acer saccharum (sugar maple)
Fraxinus americana (white ash)
Tilia americana (basswood)
Ostrya virginiana (ironwood)
Cornus alternifolia (alternate-leaved dogwood)
Sambucus racemosa (red elderberry)

Herbs
Arisaema triphyllum (Jack-in-the-pulpit)
Viola rotundifolia (round-leaved violet)
Actaea spp. (baneberries)
Tiarella cordifolia (foamflower)
Solidago flexicaulis (zigzag goldenrod)
Botrychium virginianum (rattlesnake-fern)
Deparia acrostichoides (silvery spleenwort)
Milium effusum (millet-grass)
Osmorhiza claytonii (Clayton's sweet-cicely)
Panax quinquefolius (ginseng)*
Polystichum acrostichoides (Christmas fern)

Rich mesic forest:

Above species plus at least several of the following species:

Adiantum pedatum (northern maidenhair fern)

Caulophyllum thalictroides (blue cohosh)

Dryopteris goldiana (Goldie's fern)*

Dicentra canadensis (squirrel-corn)*

Dicentra cucullaria (Dutchman's breeches)

Asarum canadense (wild ginger)

Carex platyphylla (flat-leaved sedge)

Carex plantaginea (plantain-leaved sedge)

Eupatorium rugosum (white snakeroot)

Sanguinaria canadensis (bloodroot)

Cypripedium pubescens (large yellow lady's-slipper)*

Viola canadensis (Canada violet)

Viola pubescens (downy yellow violet)

Aralia racemosa (spikenard)

Pyrola asarifolia (pink wintergreen)*

Osmorhiza chilensis (mountain sweet-cicely)*

Solidago calcicola (rock goldenrod)*

Carex aestivalis (summer sedge)*

Galearis spectabilis (showy orchis)*

• Rich north-temperate talus/rocky woods system

Landscape settings: talus or other rocky slopes in neutral to concave hillside slope positions, and occasionally upper-slope positions, particularly in regions of calcium-rich bedrock

Soils: overall dry-mesic with embedded dry and mesic micro-sites, well to somewhat excessively well drained; moderate to shallow depth fine sandy loams with considerable gravel and stone content with frequent outcrops, talus boulders, and/or unconsolidated stones; sometimes with a well-mixed "mull" A horizon

Spatial pattern: variable (<1 – 50+ acres), although often elliptical or broad-linear when controlled by topographic position (i.e., cliff-bases and hillside slopes)

Physiognomy: woodland to forest, with patches of un- or sparsely-vegetated lichen talus barrens

Distribution: low to mid elevations in central and southern New Hampshire (500 – 1200 ft., occasionally to 2000 ft.)

Description: This system is found on enriched talus and other rocky slopes in central New Hampshire from about 500 to 1200 ft. elevation, and occasionally up to about 2000 ft. in the low elevation valleys in the White Mountain region (Saco, Connecticut, and Androscoggin River valleys). Montane acidic talus slopes lack rich-site indicators, and on average occur at higher elevations and in the mountains well above the lowest elevation valley bottoms. Rich north-temperate talus/rocky woods differs from Appalachian rocky woods by the absence of southern oaks and southern species restricted to extreme southern New Hampshire at low elevations (<500 ft.); both are drier and rockier than rich mesic forests (overall dry-mesic). The primary diagnostic community is ***rich red oak rocky woods***, but the larger talus slope often has patches of ***temperate lichen talus barren***, and occasionally patches of ***rich mesic*** or ***semi-rich mesic sugar maple forest*** communities in mesic, colluvial areas at the base of the talus slopes. A few examples at intermediate elevations in the White Mountains (around 1500 ft.) include patches of ***spruce – birch – mountain maple wooded talus***, which is otherwise indicative of montane acidic talus systems.

Tree canopy dominants usually include *Acer saccharum* (sugar maple) and *Quercus rubra* (red oak), with lesser amounts of *Ostrya virginiana* (ironwood) and other hardwoods (softwoods are sparse or absent). Understory shrub and herb species that prefer enriched conditions differentiate this community from acidic till or talus systems. More open or unstable talus areas correspond to ***temperate lichen talus barrens*** where lichens are the dominant life-form. ***Rich mesic forest*** patches can occur at the colluvial bases of some talus slopes, and are marked by the disappearance of red oak, ironwood, beech, and rich site vines or herbs more preferential to rich rocky talus such as *Geranium robertianum* (herb Robert), *Oryzopsis racemosa* (blackseed rice-grass), *Clematis virginiana* (virgin's bower), and *Toxicodendron radicans* (poison ivy). Thus, small patches of rich mesic forest are characteristic of this system and do not necessarily indicate a larger rich mesic forest system.

Diagnostic natural communities:

- Rich red oak rocky woods (S2S3)
- Red oak - black birch wooded talus (S3S4)
- Temperate lichen talus barren (S2S3)

- Rich mesic forest (S3)
- Semi-rich mesic sugar maple forest (S4)

Peripheral or occasional natural communities:

- Spruce - birch - mountain maple wooded talus (S3)
- Montane lichen talus barren (S3)

Associated natural community systems: This system often transitions to montane rocky ridge and montane cliff systems upslope and northern hardwood – conifer forest or hemlock – hardwood – pine forest systems downslope.

Characteristic species:

Trees
Acer saccharum (sugar maple) – dom.
Quercus rubra (red oak) – dom.
Tilia americana (basswood)
Fraxinus americana (white ash)
Ostrya virginiana (ironwood)
Betula lenta (black birch)
Acer rubrum (red maple)
Betula alleghaniensis (yellow birch)
Betula papyrifera (paper birch)

Shrubs and vines (rich-site indicators)
Cornus rugosa (round-leaved dogwood)
Clematis virginiana (virgin's bower)
Toxicodendron radicans (climbing poison ivy)
Corylus cornuta (beaked hazel-nut)
Rubus odoratus (purple-flowering raspberry)

Herbs (rich-site indicators)
Saxifraga virginiensis (early saxifrage)
Geranium robertianum (herb Robert)
Juglans cinerea (butternut)
Aralia racemosa (spikenard)
Oryzopsis racemosa (blackseed rice-grass)
Milium effusum (millet-grass)
Asarum canadense (wild ginger)
Carex rosea/radiata (rosey sedge)
Carex platyphylla (flat-leaved sedge)
Carex sprengelii (long-beaked sedge)
Potential rare species:
Geranium carolinianum (Carolina cranesbill)*
Dentaria laciniata (cutleaf toothwort)*
Adlumia fungosa (climbing fumitory)*
Panax quinquefolius (ginseng)*
Carex aestivalis (summer sedge)*

• Rich Appalachian oak rocky woods system

Landscape settings: talus or other rocky slopes in neutral to concave hillside slope positions, and occasionally upper-slope positions, particularly in regions of calcium-rich bedrock

Soils: overall dry-mesic with embedded dry and mesic micro-sites, well to somewhat excessively well drained; moderate to shallow depth fine sandy loams with considerable gravel and stone content with frequent outcrops, talus boulders, and/or unconsolidated stones; sometimes with a well-mixed "mull" A horizon

Spatial pattern: small to large patches (1 – 200+ acres); variably shaped, although often elliptical or broad-linear when controlled by topographic position (i.e., cliff-bases and hillside slopes)

Physiognomy: woodland to forest, rarely with patches of un- or sparsely-vegetated lichen talus barrens

Distribution: low elevations in southern New Hampshire, mostly below 500 ft., ranging to ca. 1000 ft.

Description: This system is the southern equivalent of rich north-temperate talus/rocky woods system. It occurs on hillsides mostly below 500 ft. and of more southerly distribution (e.g., within 30 miles of the coast or Massachusetts border) on rocky to shallow till hillsides. It is indicated by a host of southern plants that do not occur further north or at higher elevations. There are two primary natural communities, ***rich Appalachian oak rocky woods*** and ***red oak – ironwood – Pennsylvania sedge woodland***. ***Temperate lichen talus barrens*** are small and rare in this system, as are patches of ***rich mesic forest***. This system typically transitions to more nutrient poor, rocky conditions on the ridge tops classified as Appalachian oak rocky ridge system, but occasionally they occupy the ridgetop settings as well where the ***red oak – ironwood – Pennsylvania sedge woodland*** community dominates. The hillsides on which this system occurs includes definite talus, other unconsolidated, loose rocky slopes, and relatively shallow till soils with occasional outcrops.

Many of the diagnostic plants listed for rich north-temperate talus/rocky woods occur in this system. Indicators of the primary community (***rich Appalachian oak rocky woods***) in this more southern system include hickories, flowering dogwood, oaks other than red oak, and a wide variety of herbs and shrubs that reach their northeastern limit in southern NH. Areas dominated by *Carex pensylvanica* (Pennsylvanian sedge) lawns indicate the ***red oak – ironwood – Pennsylvania sedge woodland*** community, which tends to occur somewhat higher on hill side-slopes and even onto adjacent ridgelines compared to the ***rich Appalachian oak rocky woods*** community. These two communities are frequently found together in this system.

Diagnostic natural communities:

- Rich Appalachian oak rocky woods (S1)
- Red oak - ironwood - Pennsylvania sedge woodland (S2)
- Red oak - hickory wooded talus (S1S2)

Peripheral or occasional natural communities:

- Rich mesic forest (S3)
- Semi-rich Appalachian oak - sugar maple forest (S2S3)
- Appalachian oak - pine rocky ridge (S3)
- Chestnut oak forest/woodland (S1S2)
- Temperate lichen talus barren (S2S3)

Associated natural community systems: This system typically transitions to oak – pine forest systems or sometimes hemlock – hardwood – pine forest systems. More xeric conditions along adjacent ridgetops often mark the transition to Appalachian oak rocky ridge systems that lack the rich-site indicators of rich Appalachian oak rocky woods systems.

Characteristic species:

Rich Appalachian oak rocky woods (plants listed for rich north-temperate talus/rocky woods system are also found in this system):

Southern species generally not found in north-temperate type:

Trees and shrubs

Quercus alba (white oak)
Carya ovata (shagbark hickory)
Carya ovalis (sweet pignut hickory)
Carya cordiformis (bitternut hickory)
Carya glabra (pignut hickory)
Quercus prinus (chestnut oak)
Quercus velutina (black oak) - ridgetops
Quercus coccinea (scarlet oak) - ridgetops
Cornus florida (flowering dogwood)
Viburnum rafinesquianum (downy arrowwood)*

Herbs

Asplenium platyneuron (ebony spleenwort)
Ranunculus fascicularis (early buttercup)*
Aster patens (skydrop aster)*
Arabis canadensis (sickle-pod)*
Arabis laevigata (smooth rock-cress)*
Arabis missouriensis (Missouri rock-cress)*
Aureolaria virginica (downy false-foxglove)*
Carex retroflexa (reflexed sedge)*
Lespedeza virginica (slender bush-clover)*
Pycnanthemum incanum (hoary mountain mint)*
Paronychia canadensis (smooth-forked chickweed)*
Anemonella thalictroides (rue anemone)*
Asclepias quadrifolia (four-leaved milkweed)*
Woodsia obtusa (blunt-lobed woodsia)*.
Muhlenbergia sobolifera (sprout muhlenbergia)*
Viola pedata (bird's-foot violet)*

FORESTS ON TILL, SAND PLAIN, AND OTHER FLUVIAL MATERIALS WITH AN INFREQUENT FIRE HISTORY

The forests in this section dominate most of New Hampshire's landscape. Most of the forests of New Hampshire are characteristic of the nutrient-poor end of the spectrum, primarily due to the prominence of granitic and other low base-cation yielding glacial drift. The more common forest systems described here are characterized by a broad range of moisture regimes and substrates including dry to mesic conditions, glacial till, fluvial river terraces, sand plains that are not burned frequently, and even stabilized talus areas that are not enriched or open canopied. Enriched hardwood forests are unique among NH forests and are described as separate systems. The other upland systems (described above) occupy unique or extreme settings embedded as small or large patches within the more common forest mosaic: alpine summits, rocky balds, cliffs and talus, fire-burned sand plains, and those found on New Hampshire's short but distinct shoreline.

The five major forest systems described for New Hampshire relate closely to continental and regional-scale vegetation patterns. At the continental scale, broad climatic zones with similar vegetation are called biomes. The boreal forest and eastern deciduous forest biomes are the two North American biomes that relate most closely to New Hampshire's forests. The boreal forest biome is a subarctic conifer forest that dominates the polar regions of North America, Europe, and Asia. The eastern deciduous forest biome covers much of eastern North America south of the boreal forest. These biomes can be divided into regional units based on the distribution patterns shared by many species that are centered in different parts of the biome.

New Hampshire sits at the cross-roads between these two biomes. The forests of the White Mountains, northern New Hampshire and higher elevations to the south (e.g., > 1400 ft.) are characterized by red spruce, balsam fir, and the so-called northern hardwoods (sugar maple, yellow birch, and American beech). These species are restricted to one or the other of these biomes, or are part of an intermediate north temperate distribution referred to as Alleghanian. Alleghanian species have a range that stretches from the glaciated northeastern United States and adjacent southern Canada to the Great Lakes region, with an extension southward along the Appalachian Mountains. Thus, they are not found in the boreal forest, nor are they broadly distributed in the eastern deciduous forest. Alleghanian species include red spruce, yellow birch, heartleaf paper birch, white pine, and hemlock. New Hampshire's northern forests also have species with true transcontinental boreal distributions such as balsam fir and quaking aspen. The middle and lower elevation forests of central and southern New Hampshire are characterized by the relative scarcity of red spruce, balsam fir, and lower frequency of the northern hardwood species, particularly yellow birch and sugar maple. Hemlock and beech are the primary late-successional dominants in this region, and oaks and white pine increase in prominence. Southern New Hampshire marks the transition to the so-called central hardwood or Appalachian oak region, where forests are dominated by oaks, hickories, and pines with less beech and hemlock than in central New Hampshire.

We describe five matrix-forest systems in New Hampshire. The forests of northern New Hampshire and higher elevations of central and western parts of the state are divided into three systems: lowland spruce – fir forest/swamp, high-elevation spruce – fir, and northern hardwood – conifer forest systems. The forests of central and southern New Hampshire and low elevations in major mountain valleys to the north correspond to two matrix forest systems: an oak – pine forest system centered to the south and a hemlock – hardwood – pine forest system. The latter type is a transitional forest that marks a "tension zone" between oak – pine forests to the south and lower elevations and northern hardwood forests to the north or higher elevations. This approach consistent with well-established forest-region patterns described by

others (i.e., Westveld 1956; Cogbill 2002), but is more specific in terms of the groups of natural communities that comprise the systems that characterize these major regions.

• Lowland spruce-fir forest/swamp system

Landscape settings: valley bottoms, lowland flats, and lake basins

Soils: mostly on moderately well to poorly drained glacio-fluvial and firm till mineral soils (sand to silt loams, sometimes gravelly), less frequently on loose till; may contain inclusions of well and very poorly drained soils; generally weakly minerotrophic, acidic

Spatial pattern: large patch to extensive (5 – 500+ acres); linear to broad-linear or irregular; further south, occurs in more isolated small patches; internal zonation of communities typically relates to soil drainage

Physiognomy: forest to woodland

Distribution: well developed and most common north of the White Mountains from 1000 – 2500 ft.; less frequent in the White Mountains; infrequent in the higher valley bottoms south of the mountains

Description: This system is a mosaic of ***lowland spruce - fir forest*** and ***red spruce swamp*** communities that occur on mineral soils. In northern New Hampshire, these communities intergrade in complex ways on the ground with various expressions ranging mostly from well or moderately well drained upland forests to poorly or very poorly drained swamps. Somewhat poorly drained soils are intermediate and very common. The average condition for red spruce swamps is acidic and poorly drained, with shallow, well decomposed organic soils (10 – 40 cm) over sandy to silty mineral soil. These systems often grade at the very poorly drained end of the spectrum to black spruce peat swamps. In the White Mountains and in other moderate elevation mineral swamp settings where the gradient is not so gradual, ***red spruce swamp*** can be the primary community with an abrupt transition to a narrow spruce - fir forest border or direct transition to hardwood forest or high-elevation spruce-fir systems. Thus, it is more minerotrophic than black spruce peat swamps, but less so than northern white cedar or near-boreal hardwood-conifer minerotrophic swamp systems.

Lowland spruce – fir forests have a well developed conifer canopy, a sparse tall shrub understory, sparse to moderate cover of ferns and dwarf shrubs, and moderate to high cover of bryophytes.

Diagnostic natural communities:

- Red spruce swamp (S3)
- Lowland spruce - fir forest (S3)
- Montane black spruce - red spruce forest (S1)

Associated natural community systems: Black spruce peat swamp systems occur on adjacent very poorly drained peat soils. In more minerotrophic settings this system can be adjacent and transition into

northern white cedar or near-boreal hardwood-conifer minerotrophic swamp systems. Upslope, lowland spruce – fir forest/swamps typically transition to northern hardwood – conifer systems. The transition to red spruce swamp is marked by well developed hummock – hollow topography with wet hollows and higher cover of cinnamon fern and bryophytes.

Characteristic species:

Lowland spruce - fir forest:

Trees and tall shrubs
Picea rubens (red spruce) – dom.
Abies balsamea (balsam fir) – dom.
Betula papyrifera (paper birch) – com.
Betula alleghaniensis (yellow birch) – com.
Betula cordifolia (heartleaf birch) – occ.
Picea glauca (white spruce) – occ.
Picea mariana (black spruce) – occ.
Sorbus decora (showy mountain ash)
Sorbus americana (American mountain ash)
Nemopanthus mucronatus (mountain holly)

Dwarf shrubs
Cornus canadensis (bunchberry)
Linnaea borealis (twinflower)
Amelanchier bartramiana (Bartram's serviceberry)
Coptis trifolia (goldthread)
Vaccinium myrtilloides (velvet-leaf blueberry)
Gaultheria hispidula (creeping snowberry)

Herbs
Dryopteris campyloptera (mountain wood fern)
Dryopteris intermedia (intermediate wood fern)
Listera cordata (heart-leaved twayblade)*
- moist or seepy areas
Listera convallarioides (lily-leaved twayblade)*
- moist or seepy areas

Bryophytes
Bazzania trilobata (liverwort)
Dicranum scoparium (moss)
Hypnum curvifolium (moss)
Pleurozium schreberi (moss)
Ptilium crista-castrensis (moss)
Brotherella recurvans (moss)
Bazzania denudate (liverwort)
Scapania nemoria (liverwort)
Drepanocladus uncinatus (moss)
Pohlia nutans (moss)
Sphagnum russowii (peat moss)
Sphagnum girgenshonii (peat moss)

Occasional species absent or uncommon in the ***high elevation spruce – fir***:

Aralia nudicaulis (wild sarsaparilla)
Acer pensylvanicum (striped maple)
Trillium erectum (wakerobin)
Tiarella cordifolia (foamflower)
Picea glauca (white spruce)
Osmunda cinnamomea (cinnamon fern)

• High-elevation spruce-fir forest system

Landscape settings: mountain side-slopes

Soils: mostly loose and firm cryic tills; also on stabilized talus

Spatial pattern: large patch to matrix (<10 – 1000+ acres); irregular shapes along mountain tops and ridges

Physiognomy: forest

Distribution: generally from 2500 - 4500 ft.; lower on side slopes with poor, rocky soils

Description: This system corresponds to the *Picea rubens* (red spruce) and *Abies balsamea* (balsam fir) dominated forests of higher elevation mountains in New Hampshire between 2500 and 4500 ft. (locally higher and lower). There are two dominant communities in this system: ***high-elevation spruce – fir forest*** that occurs mostly between 2500 – 3500 ft., and ***high-elevation balsam fir forest*** that occurs from about 3500-4500 ft. This system occurs locally lower on ridges and other rocky or infertile sites, and locally higher on relatively protected sites (e.g., ravines up to ca. 5200 ft.).

High-elevation balsam fir forest occurs below the krummholz zone and is dominated by balsam fir with little or no red spruce and less *Betula cordifolia* (heartleaf birch) than at lower elevations. The canopy height here is typically in the 2-10 m range, reduced from the taller stature trees at lower elevations (which grow to 20-25 m height). These short trees ultimately diminish to krummholz stature (<2 m) at treeline. Pease's (1964) concept of balsam fir "scrub" probably includes both krummholz and the upper portion of balsam fir forest zone where the fir trees are scrubby in nature and of low stature (2-5 m) from about 4200-4500+ ft. in elevation. Here the lower branches of balsam fir trees can form dense thickets, punctuated by a partial woodland canopy of narrow fir spires. High-elevation fir forests can form patches of wind-induced mortality known as "fir-waves." Fir waves are linear patches of blow-down or standing dead trees oriented perpendicular to the prevailing wind, and arranged in a progression of waves of different ages of resulting regeneration adjacent to one another. A common theory suggests that the trees primarily die from the death of needles and roots due to chronic wind stress.

The ***high-elevation spruce – fir forest*** occurs at lower elevations and typically contains red spruce, balsam fir, and heartleaf birch. The specific composition of these forests is much influenced by the disturbance history, and to a lesser extent by soils and elevations within the zone. Variation in species composition is noticeable along a moisture gradient: in drier conditions the heaths and other dry-site species dominate (transitional to **the *red spruce – heath – cinquefoil rocky ridge*** community on shallow-to-bedrock sites); in moister conditions there is greater bryophyte cover. Characteristic birds include arctic three-toed woodpecker, black-backed woodpecker, spruce grouse, Bicknell's thrush, black poll warbler, yellow-rumped warbler, boreal chickadee, and others.

The transition from the high-elevation spruce – fir forest system to northern hardwood – conifer forest systems is often marked by the ***northern hardwood – spruce – fir forest*** community. This community is characterized by spruce, fir, and northern hardwoods (yellow birch, beech, sugar maple). It forms a narrow to broad zone between the two systems, and it is arguable whether this community is more indicative of one or the other. Depending on disturbance and cutting history, some examples of current hardwood or mixed forests will eventually succeed to conifer dominance (e.g., ***high-elevation spruce –***

fir forest). However, examples of ***northern hardwood –spruce – fir forests*** that are likely to stay more mixed over the long term are probably most closely aligned with ***sugar maple – beech – yellow birch forests*** because the northern hardwoods have not been excluded by the climatic and poorer soil conditions closely associated with their disappearance at higher elevations in the ***high-elevation spruce – fir forest***.

Soils in this system are generally very nutrient-poor, acidic Inceptisols or Spodosols with a deep, slowly decomposing humus layer and the variable presence of a grey, leached E (elluviated) horizon. Drainage varies from well to moderately-well drained (somewhat poorly to poorly drained soils are more typical of lowland spruce - fir forest and spruce - fir swamps). Litter of conifers has low nutrient quality and contributes to organic matter accumulation. Cloud-intercept contributes a significant amount of moisture to this system, particularly in the balsam fir zone. Colder temperatures and deep, late-melting snowpacks at high elevations also contribute to higher moisture levels, lower soil temperatures, a shortened growing season, and accumulation of humus compared to lower elevation northern hardwood forests.

Diagnostic natural communities:

- High-elevation spruce - fir forest (S4)
- High-elevation balsam fir forest (S3S4)

Peripheral or occasional natural communities:

- Northern hardwood - spruce - fir forest (S4)
- Montane landslide (S3S4)

Associated natural community systems: This system transitions to alpine tundra, alpine ravine/snowbank, subalpine heath – krummholz/rocky bald, or montane rocky ridge and slab systems at higher elevations, and northern hardwood – conifer forest systems at lower elevations.

Characteristic species:

Trees and tall shrubs

Abundant species

Picea rubens (red spruce)

Abies balsamea (balsam fir)

Betula papyrifera (paper birch)

Betula alleghaniensis (yellow birch)

Betula cordifolia (heartleaf birch)

Occasional species:

Picea mariana (black spruce) – higher elevs.

Sorbus decora (showy mountain ash)

Sorbus americana (American mountain ash)

Nemopanthus mucronatus (mountain holly)

Dwarf shrubs

Cornus canadensis (bunchberry)

Linnaea borealis (twinflower)

Amelanchier bartramiana (Bartram's serviceberry)

Coptis trifolia (goldthread)

Vaccinium myrtilloides (velvet-leaf blueberry)

Gaultheria hispidula (creeping snowberry)

Herbs

Dryopteris campyloptera (mountain wood fern)

Dryopteris intermedia (intermediate wood fern)

Huperzia lucidula (shining clubmoss)

Oxalis montana (northern wood sorrel)

Clintonia borealis (blue-bead lily)

Listera cordata (heart-leaved twayblade)* - moist or seepy areas

Listera convallarioides (lily-leaved twayblade)* - moist or seepy areas

Bryophytes

Bazzania trilobata (liverwort)

Dicranum scoparium (moss)

Hypnum curvifolium (moss)

Pleurozium schreberi (moss)

Ptilium crista-castrensis (moss)

Brotherella recurvans (moss)

Bazzania denudate (liverwort)

Scapania nemoria (liverwort)

Drepanocladus uncinatus (moss)

Pohlia nutans (moss)

Sphagnum russowii (peat moss)

Sphagnum girgenshonii (peat moss)

• Northern hardwood - conifer forest system

Landscape settings: mountains, high hills, and mountain valleys

Soils: loose and firm glacial till, glacio-fluvial soils (e.g., river and kame terraces, outwash), stabilized talus

Spatial pattern: matrix (<10 – 1000+ acres); irregular and linear zonation of component communities

Physiognomy: forest

Distribution: 1400-2500 ft. elevation in northern NH and along the western highlands; occasionally found down to about 1000 ft. elevation in cool, mesic settings

Description: New Hampshire's northern hardwood forests are characterized by *Fagus grandifolia* (American beech), *Acer saccharum* (sugar maple), and *Betula alleghaniensis* (yellow birch). These northern hardwood forests are positioned latitudinally and elevationally between the high-elevation spruce - fir forest and hemlock – hardwood – pine forest systems. Northern hardwood forests are generally found between 1400-2500 ft. in elevation in northern NH and along the western highlands (Sunapee Uplands subsection), although the tolerance range of individual species varies. Some occurrences can be found down to about 1000 ft. elevation.

The upslope ecotone to spruce - fir forest is marked by the appearance of *Picea rubens* (red spruce), *Abies balsamea* (balsam fir), the increased importance of yellow birch, and the disappearance of sugar maple and beech; the downslope ecotone to the hemlock – hardwood – pine forest system is marked by the appearance of more *Tsuga canadensis* (hemlock) along with *Quercus rubra* (red oak), *Pinus strobus* (white pine), and occasionally *Ostrya virginiana* (ironwood) and decreased dominance of yellow birch and sugar maple.

The matrix forest community type of this system, ***sugar maple – beech – yellow birch forest***, mixes with patches of several other communities. ***Hemlock – beech – northern hardwood forests*** occur at lower elevations (800 - 2000 ft.) and are differentiated from the matrix community by a substantial presence of hemlock. It occurs in valley bottoms and lower mountain slopes of the White Mountains, and middle to higher elevations of hills and low mountains of the Sunapee Uplands subsection of western New Hampshire. ***Hemlock – spruce – northern hardwood forests*** are also found at elevations below 2000 ft. This is a conifer to mixed community type with considerable hemlock and spruce mixing with variable amounts of birches, other northern hardwoods, balsam fir, and sometimes white pine. It occurs primarily on river terraces, stream ravines, and compact till settings in the mountains where it transitions to more pure northern hardwoods on better soils (e.g., fine tills). ***Semi-rich mesic sugar maple forests*** are a common but relatively small part of the mosaic formed by this system where there is slightly enriched till or fine river terrace sediments. Both ***beech forest*** and ***hemlock forest*** types are occasional in this and the hemlock – hardwood – pine forest systems, but generally form relatively small patches. ***Northern hardwood – spruce – fir forests*** mark the transition to ***high-elevation spruce – fir forest***, but in most cases are considered part of the northern hardwood – conifer forest system because the hardwood trees that disappear in ***high-elevation spruce – fir*** (due to climate and/or soil conditions) are still present. Some spruce – fir or mixed forests that have been cut or heavily disturbed may currently support a hardwood or mixed forest canopy, and may or may not succeed to greater spruce – fir prominence.

Diagnostic natural communities:

- Sugar maple - beech - yellow birch forest (S5) – matrix forest type
- Hemlock – spruce – northern hardwood forest (S3S4)
- Hemlock - beech - northern hardwood forest (S4)
- Semi-rich mesic sugar maple forest (S3S4)
- Northern hardwood - spruce - fir forest (S4)

Peripheral or occasional natural communities:

- Beech forest (S4)
- Hemlock forest (S4)

Associated natural community systems: Northern hardwood – conifer forest systems transition upslope to high-elevation spruce - fir forest systems. Downslope they transition to either 1) hemlock – hardwood – pine forest systems, especially in low elevation valleys of White Mountains and further south; or 2) lowland spruce – fir forest/swamp systems in the North Country and some valley bottoms in the White Mountains.

Characteristic species:

Characteristic species of the northern hardwood – conifer forest system:

Trees - hardwoods
Acer saccharum (sugar maple)
Fagus grandifolia (American beech)
Betula alleghaniensis (yellow birch)
Acer rubrum (red maple)
Betula papyrifera (paper birch)
Acer pensylvanicum (striped maple)
Prunus pensylvanica (pin cherry)
Fraxinus americana (white ash)

Trees - conifers
Tsuga canadensis (hemlock)
Abies balsamea (balsam fir)
Picea rubens (red spruce)
Pinus strobus (white pine) – infreq. at low elev.

Understory species absent or less frequent in communities of hemlock – hardwood – pine forest system:

Herbs and fern allies
Clintonia borealis (blue-bead lily)
Huperzia lucidula (shining clubmoss)
Dryopteris campyloptera (mountain wood fern)
Oxalis montana (northern wood sorrel)
Aster acuminatus (whorled aster)
Streptopus lanceolatus (rose twisted stalk)

Shrubs & dwarf shrubs
Acer spicatum (mountain maple)
Viburnum lantanoides (hobblebush)
Cornus canadensis (bunchberry)
Coptis trifolia (goldthread)
Lonicera canadensis (Canadian honeysuckle)
Polystichum braunii (Braun's holly fern)

Species common to communities of both systems:

Dryopteris intermedia (intermediate wood fern)
Aralia nudicaulis (wild sarsaparilla)
Trientalis borealis (starflower)
Uvularia sessilifolia (sessile-leaved bellwort)
Epifagus virginiana (beechdrops)
Maianthemum canadense (Canada mayflower)
Mitchella repens (partridgeberry)
Monotropa uniflora (Indian pipes)

Species infrequent in northern hardwood – conifer system (characteristic of hemlock – hardwood – pine forests):

Betula lenta (black birch)
Betula populifolia (gray birch)
Prunus serotina (black cherry)
Quercus rubra (red oak)
Hamamelis virginiana (witch hazel)
Gaultheria procumbens (wintergreen)
Viburnum acerifolium (maple-leaved viburnum)

• Hemlock - hardwood - pine forest system

Landscape settings: high to low hills, mountain valleys, lowland flats

Soils: loose and firm glacial till, glacio-fluvial soils (e.g., river and kame terraces, outwash), occasionally on stabilized talus

Spatial pattern: matrix (<10 – 1000+ acres); irregular and linear zonation of component communities

Physiognomy: forest

Distribution: below 1500 ft. elevation in central and southern NH, extending into low elevations of White Mountains.

Description: This is a transitional forest region or "tension zone" in New Hampshire that is positioned latitudinally and elevationally between northern hardwood - conifer forests to the north and higher elevations (mostly >1400 ft.) and oak - pine (Appalachian or central hardwood) forests to the south and lower elevations (mostly < 900 ft.). This transitional forest lacks most boreal species and central hardwood species that characterize these other forests, but has many Alleghanian species such as *Pinus strobus* (white pine) and *Tsuga canadensis* (hemlock). Many of the other species of this system are common throughout eastern United States. Hemlock – hardwood – pine forests are found throughout the state from the White Mountains south below about 1500 feet. Dry-mesic to mesic glacial till soils are most abundant, but this system also occupies river terraces, sand plains, and stabilized talus areas covered by a forest canopy. It includes dry, sandy soils with red oak and white pine that have not been burned on a historically frequent enough interval to support pitch pine sand plains system. These areas are likely to be successional to hemlock and/or beech over the long term without the return of fire.

The main matrix forest community that defines this system is ***hemlock – beech – oak – pine forest***. Hemlock and beech are the primary late-successional trees in this community, with maximum ages of about 500 and 300 years, respectively. *Quercus rubra* (red oak) and *Pinus strobus* (white pine) are also typically abundant, in contrast to their absence or low abundance in northern hardwood – conifer forest systems. Most of the old-field white pine stands in central NH are successional examples of this system. *Acer saccharum* (sugar maple) and *Betula alleghaniensis* (yellow birch) are occasional but of less importance than in northern hardwood – conifer forests. They are most frequent in mesic areas such as concavities and along drainages where *Fraxinus americana* (white ash) is frequent, or locally abundant in patches of ***semi-rich sugar maple forests***. *Picea rubens* (red spruce) and *Abies balsamea* (balsam fir) are generally sparse or absent, but are occasional on the lower slopes of some mountains south of the White Mountains (i.e., Ossipee Mountains, Mt. Monadnock). Central hardwood/Appalachian species are essentially absent, including hickories (*Carya* spp.), oaks (*Quercus* spp.) other than red oak, dogwoods, and southern herbs (see oak – pine forest description). These more southern species do appear as occasional outposts as the more definitive oak – pine forests to the south are approached.

Variation in soils or landscape position within this system explains much of the variation in community composition. ***Hemlock forests*** often occur in ravines or extremely rocky sites; ***beech forests*** occur on coarse washed till soils; ***semi-rich mesic sugar maple forests*** occur in colluvial landscape positions or associated with bedrock or till with greater base-cation contributions to the soil; ***hemlock – beech – northern hardwood forest*** occurs in more mesic settings or at higher elevations near the transition to

northern hardwood – conifer forests; ***dry red oak – white pine forests*** occur on sandy or rocky soils that may perpetuate oak and pine dominance locally with repeated disturbance.

Diagnostic natural communities:

- Hemlock - beech - oak - pine forest (S5) – matrix forest type
- Hemlock forest (S4)
- Beech forest (S4)
- Hemlock – white pine forest (S4)
- Dry red oak – white pine forest (S3S4)
- Semi-rich mesic sugar maple forest (S3S4)

Peripheral or occasional natural communities:

- Hemlock - beech - northern hardwood forest (S4)

Associated natural community systems: Hemlock – hardwood – pine forest systems transition upslope and northward to northern hardwood – conifer forest systems. To the south and sometimes lower elevations or onto rocky, dry or frequent-fire landscapes this system transitions to oak – pine forest, Appalachian oak rocky ridge, or pitch pine sand plain systems.

Plants that tend to be more prominent in hemlock – hardwood – pine forests than in northern hardwood – conifer forests include *Hamamelis virginiana* (witch hazel), *Betula lenta* (black birch), *Prunus serotina* (black cherry), *Ostrya virginiana* (ironwood), *Viburnum acerifolium* (maple-leaved viburnum), *Gaultheria procumbens* (wintergreen), and *Gaylussacia baccata* (black huckleberry).

Characteristic species:

Characteristic tree species of the hemlock – hardwood – pine forest system:

Tsuga canadensis (hemlock)
Fagus grandifolia (American beech)
Quercus rubra (red oak)
Pinus strobus (white pine)
Acer rubrum (red maple)
Betula papyrifera (paper birch)
Fraxinus americana (white ash)
Betula lenta (black birch)
Betula populifolia (gray birch)
Prunus serotina (black cherry)

Shrubs mostly absent from northern hardwood - conifer forests:

Hamamelis virginiana (witch hazel)
Viburnum acerifolium (maple-leaved viburnum)
Gaultheria procumbens (wintergreen)

Herbs common to communities of both systems:
Dryopteris intermedia (intermediate wood fern)
Aralia nudicaulis (wild sarsaparilla)
Trientalis borealis (starflower)
Uvularia sessilifolia (sessile-leaved bellwort)
Epifagus virginiana (beechdrops)

Herbs common to both systems (cont.):

Maianthemum canadense (Canada mayflower)
Mitchella repens (partridgeberry)
Monotropa uniflora (Indian pipes)

Understory species mostly absent in hemlock – hardwood – pine forests:

Herbs

Clintonia borealis (blue-bead lily)
Huperzia lucidula (shining clubmoss)
Dryopteris campyloptera (mountain wood fern)
Oxalis montana (northern wood sorrel)
Aster acuminatus (whorled aster)
Streptopus lanceolatus (rose twisted stalk)

Shrubs & dwarf shrubs

Acer spicatum (mountain maple)
Viburnum lantanoides (hobblebush)
Cornus canadensis (bunchberry)
Coptis trifolia (goldthread)
Lonicera canadensis (Canadian honeysuckle)
Polystichum braunii (Braun's holly fern)

• Appalachian oak - pine forest system

Landscape settings: hills, valleys, and lowland flats

Soils: loose and firm glacial till, glacio-fluvial soils (e.g., river and kame terraces, outwash), marine silts and clays

Spatial pattern: large patch to matrix (<10 – 100+ acres); irregular and linear zonation of component communities

Physiognomy: forest

Distribution: below 900 ft. elevation in southern NH; disjunct into south-central NH on steep, south-facing hills

Description: Appalachian oak – pine forest systems are found mostly below 900 ft. elevation in southern New Hampshire south of and at lower elevations than the hemlock – hardwood – pine forest system. The southern-most portions of the state are associated with the warmer and drier climatic conditions and apparently more fire-influenced landscapes that prevail south of New Hampshire in lower New England. Much of the area of these forests corresponds to nutrient-poor, dry to mesic, sandy glacial tills, and some large areas of sand plain or shallow-to-bedrock tills, particularly in the seacoast and lower Merrimack and Connecticut River valleys. Sand plains in these areas that have a frequent fire history correspond to pitch pine sand plain; those with a less-frequent fire regime (i.e., more than 50 - 100 years) are classified as oak – pine forest or sometimes hemlock – hardwood – pine forest systems depending on the composition of trees. More isolated patches of oak – pine forest systems are found to the north in central NH associated with dry rocky ridges or sand plains with a historic fire regime.

This forest system is marked by the appearance of oaks other than red oak, hickories, and numerous other southern plant species that are found in the Appalachian states and reach their northern limit in or near southern New Hampshire. It is also coincident with the decreased abundance and frequency of *Tsuga canadensis* (hemlock) and *Fagus grandifolia* (American beech) that are more prominent in hemlock – hardwood – pine forests, although both are still commonly present particularly in dry-mesic or mesic sites. Sugar maple and yellow birch are found in low abundance and are restricted to more mesic sites such as along drainages or patches of ***mesic Appalachian oak – hickory forest*** found on lower slopes or silt soils. Southern species characteristic of Appalachian oak – pine forests (see below) are diagnostic of the system even in relatively low abundance (i.e., 1-5% cover for trees) as long as they are relatively consistent and well distributed in the forested area (e.g., not single individuals across many acres).

The natural communities of this system are restricted to the southeastern part of the state and low elevations of the lower Connecticut and Merrimack River watersheds. The dominant forest types are ***mesic Appalachian oak – hickory forests*** on dry-mesic to mesic soils, and ***dry Appalachian oak – hickory forest*** on dry soil. Patches of more mesic or finer-textured soils mix with the more dominant coarser till and outwash soils along drainages, slope-bases, on silty soils of river terraces, and on marine deposits in the seacoast area. These areas often correspond to ***mesic Appalachian oak – hickory forests***, which can be locally abundant in some landscapes. Overall, dry-mesic conditions are probably the most common in the landscape, which generally corresponds to the dry-mesic variant of ***mesic Appalachian oak – hickory forest***. This community is essentially the southern counterpart to ***hemlock – beech – oak –***

pine forests that dominate central NH. In some areas of southwest New Hampshire, ***Appalachian oak – mountain laurel forest*** can be abundant. On soils that are weakly enriched, ***semi-rich Appalachian oak – sugar maple forest*** can be present. On shallow rocky till sites, ***pitch pine – Appalachian oak – heath forest*** and chestnut oak forest/woodland can intersperse with the dominant ***dry Appalachian oak – hickory forest***.

Diagnostic natural communities:

- Dry Appalachian oak - hickory forest (S1S3)
- Mesic Appalachian oak – hickory forest (S2S3)
- Appalachian oak - mountain laurel forest (S3)
- Semi-rich Appalachian oak - sugar maple forest (S2S3)

Peripheral or occasional natural communities:

- Pitch pine - Appalachian oak - heath forest (S1)
- Chestnut oak forest/woodland (S1S2)
- Dry river bluff (S2?)

Associated natural community systems: At more northern locations or towards more mesic or higher elevation locations, this forest system is transitional to hemlock – hardwood – pine forest system. It transitions to pitch pine sand plain systems in more fire-prone settings, and to Appalachian oak rocky ridge systems in shallow-to-bedrock landscapes.

Characteristic species:

Southern species diagnostic of Appalachian oak – pine forests (many species of hemlock – hardwood – pine forests may also be present):

Quercus alba (white oak)
Quercus velutina (black oak)
Quercus coccinea (scarlet oak)
Quercus alba (white oak)
Quercus prinus (chestnut oak)
Carya spp. (hickories)
Pinus rigida (pitch pine)
Sassafras albidum (sassafras)
Kalmia latifolia (mountain laurel)
Desmodium spp. (tick-trefoils)
Cornus florida (flowering dogwood)
Cornus rugosa (flowering and round-leaved dogwoods)
Solidago odora (sweet goldenrod)*
Aureolaria spp. (foxgloves)
Baptisia tinctoria (wild indigo)

Palustrine wetland systems, clockwise from top left:

1. A poor level fen/bog system, typically small in montane settings, in a perched concavity on Mt. Monadnock. Photo DDS.
2. Sand plain basin marsh system with a ***meadow beauty sand plain marsh*** ringed by ***meadowsweet – robust graminoid sand plain marsh*** and ***highbush blueberry – winterberry shrub thicket*** communities. Photo DDS.
3. ***Red maple – Sphagnum basin swamp*** within a temperate peat swamp system. Northwood Meadows State Park. Photo DDS.
4. ***Red maple – lake sedge swamp*** within a temperate minerotrophic swamp system. Skunk cabbage (foreground) and lake sedge (background). Turtle Pond, Concord. Photo DDS.
5. Emergent marsh – shrub swamp system showing a narrow fringe of ***deep emergent marsh – aquatic bed, cattail marsh,*** and ***tall graminoid emergent marsh*** communities. Burnham Brook, Canterbury. Photo DDS.
6. ***Hairy-fruited sedge – sweet gale fen*** within a medium level fen system. South River, Effingham. Photo DDS.

CLASSIFICATION OF WETLAND NATURAL COMMUNITY SYSTEMS

PALUSTRINE (NON-TIDAL, NON-RIPARIAN)

PEATLANDS

Open peatland communities can be grouped into five categories based on vegetation structure: (1) mud-bottoms, open moss lawns, and flarks; (2) dwarf- and medium-shrub bogs and poor fens; (3) sedge and shrub/graminoid fens; (4) tall shrub thicket/sparse woodlands; and (5) marshy peatland margin communities. Most peatland examples have several to many natural communities from some or all of these structural categories. The factors that appear to most strongly control which communities occur together in a repeating way within peatlands are a) the source and minerotrophic status of water; and b) the broad climate regime. The sources of water and its characteristics are discussed below.

The terms "bog" and "fen" have been used in many different ways. From a long-term peatland-development perspective, the term "bog" is usually applied only to ombrogenous peatlands that are strictly rain-fed. In this sense, New Hampshire has no known true bogs, but does contain a wide variety of "fens," or peatlands whose development is controlled in part by topogenous (upland runoff), limnogenous (stream or lake), or soligenous (groundwater) sources of water. Floristically, however, New Hampshire does contain peatland vegetation that is largely isolated from the influence of upland runoff, stream or lake water, or seepage, and is similar to vegetation that occurs in ombrogenous settings. We apply the term "bog" to plant communities that have pHs below 4.0 and only have species restricted to oligotrophic conditions. Other peatlands are considered fens. The 4.0 cutoff was shown by Wells (1996) to be a significant and convenient cutoff in Atlantic Canada peatlands. In these peatlands, pHs of 4.0 corresponded well to specific levels of calcium, iron, nitrogen, and magnesium that marked the transition from ombrotrophic conditions of bogs to the more minerotrophic conditions of fens. Data from New Hampshire (Sperduto et al. 2000a) are consistent with this cut-off as evidenced by the absence of species indicative of minerotrophic conditions at pHs below 4.0 in most plots.

It is also important to recognize that the vegetation of bogs and fens change at different rates depending on conditions. Some are quite stable over long periods, changing slowly over long time frames as peat accumulates, while others undergo rapid change and succession over much shorter time frames in response to natural or human disturbances. For example, peatlands in lake basins or those associated with streams (e.g., medium level fen systems) may be periodically flooded by beavers. Flooding can result in significant vegetation change, particularly if the peat mat is grounded instead of floating (Mitchell and Niering 1993). Emergent marsh and aquatic vegetation can become established where ericaceous shrubs once grew. However, over the long term water levels could change or peat build-up could resume as the basin continues to accumulate organic matter. Even some kettle hole bogs, which are commonly thought to have relatively stable water levels, have been shown to exhibit broad fluctuations and corresponding changes in vegetation (Miller 1996). Thus, in contrast to the common impression that all peatlands are stable, slowly changing systems, some of the variation we see among them is due to natural or human disturbances over the short term.

Open peatland system descriptions below are based on minor refinements of analyses described in Sperduto et al. (2000a), Sperduto et al. (2000b) and descriptions in Neid (2002) and Sperduto and Nichols (2004).

• Alpine/subalpine bog system

Landscape settings: concavities on ridges and on moderate to steep slopes over bedrock in subalpine and alpine zones

Soils: poorly to moderately well decomposed peat soils over bedrock, generally less than 75 cm deep; oligotrophic; pHs less than 4.0; topogenous to soligenous water sources

Spatial pattern: small patch (<1 - 5 ac); circular to irregular shape; concentric zonation or uniform

Physiognomy: dwarf shrub and moss/liverwort lawns

Distribution: restricted to the White Mountains

Description: This system includes sloping and level peatlands that occur in the subalpine and alpine zone from 2900-4900 ft. elevation in the White Mountains. They are small (less than an acre to several acres max) and occur in concavities on ridges, and on moderate to steep slopes over bedrock where some combination of limited drainage, the "fog-belt" subalpine climate, late melting snowpacks, and self-maintaining *Sphagnum* (peat moss) mats contribute to peat accumulation. Sloping peatlands are largely restricted to northern climates, and in New Hampshire they are restricted to the White Mountains and the northern part of the state. Here the cold wet climate and low evapotranspiration combine to allow peat to accumulate on sloping ground. Alpine/subalpine bogs are dominated primarily by lowland bog plants found in poor level fen/bog systems, but are distinguished from them by alpine and subalpine plants.

Alpine/subalpine bog systems contain one or more of three peatland community types (see below). While sloping peatlands are a unique characteristic of some alpine/subalpine peatlands, degree of wetness appears to be a more important determinant of species composition and natural community type than slope per se. Many examples of this system contain both ***wet alpine/subalpine bogs*** (very poorly drained concavities and occasionally on slopes) and ***wooded subalpine bog/heath snowbanks*** (sloping to level ground, less wet, more black spruce and balsam fir, but still with thick, peaty organic soils). The wet bogs have several wet-site bog species that are absent in ***wooded subalpine bog/heath snowbanks***. The ***wooded subalpine bog/heath snowbanks*** occur as a border zone around wetter bogs or in association with late melting snowbank areas, and have more black spruce and balsam fir. ***Subalpine sliding fens*** are boggy peat mats on the brow of some high elevation cliffs that are subject to sloughing off the cliff-edge, and contain the rare *Calamagrostis pickeringii* (Pickering's reed bent-grass).

Diagnostic natural communities:

- Wet alpine/subalpine bog (S1)
- Wooded subalpine bog/heath snowbank (S1S2)
- Subalpine sliding fen (S1)

Associated natural community systems: In parts of the White Mountains alpine/subalpine bog systems form a mosaic with subalpine heath/krummholz systems that have collectively been referred to as “heath

balds" (Fahey 1976; Doyle 1987). These "heath balds" occur mostly below 4000 ft. elevation on flat to gently sloping ridgetops of the Mahoosuc, Carter-Moriah, and Baldface Ranges. Smaller examples are found in several other scattered locations. Otherwise alpine/subalpine bog systems are found either within the higher elevation alpine tundra mosaic in the Presidential Range, or embedded as patches within high-elevation spruce-fir forest systems.

Characteristic species:

Species characteristic of alpine bogs but absent or rare in poor level fen/bogs of lowlands:

Wet alpine/subalpine bog:

Trees – absent or sparse

Dwarf shrubs
Alpine/subalpine indicators:
Vaccinium uliginosum (alpine bilberry)
Empetrum nigrum (black crowberry)
Rubus chamaemorus (baked apple berry)
Vaccinium vitis-idaea (mountain cranberry)
Other dwarf shrubs:
Vaccinium oxycoccos (small cranberry)
Kalmia polifolia (bog laurel)
Ledum groenlandicum (Labrador tea)
Chamaedaphne calyculata (leatherleaf) - >10%
Kalmia angustifolia (sheep laurel) - <10%

Herbs
Eriophorum vaginatum (hare's-tail)
Scirpus cespitosus (tussock bulrush)

Bryophytes and lichens
Peat mosses – constant & abundant
Sphagnum fuscum (peat moss)
Sphagnum capillifolium (peat moss)
Cetraria islandica (lichen)
Cladina rangiferina (lichen)

Wooded subalpine bog/heath snowbank:

Trees – prominent
Picea mariana (black spruce)
Abies balsamea (balsam fir)

Dwarf shrubs
Alpine/subalpine indicators:
Vaccinium uliginosum (alpine bilberry)
Empetrum nigrum (black crowberry)
Rubus chamaemorus (baked apple berry) – mostly absent
Vaccinium vitis-idaea (mountain cranberry)
Other dwarf shrubs:
Ledum groenlandicum (Labrador tea)
Chamaedaphne calyculata (leatherleaf) - <10%
Kalmia angustifolia (sheep laurel)

Bryophytes and lichens
Peat mosses – less frequent & abundant
Cetraria islandica (lichen)
Cladina rangiferina (lichen)

• Kettle hole bog system

Landscape settings: closed-basin, kettle hole depressions in glacial outwash or ice-contact deposits

Soils: deep, poorly decomposed peat; oligotrophic; pHs $\leq$ 4.0; topogenous

Spatial pattern: small patch (1 - 20 acre); circular to irregular shape; more or less concentric zonation

Physiognomy: sparse woodland, tall shrub, dwarf shrub, moss carpets/lawns

Distribution: broadly distributed in New Hampshire, but concentrated in the central and southern portions of the state where kettle holes are more abundant

Description: Kettle hole bogs are found where big chunks of glacial ice were stranded and partially buried in glacial outwash or other coarse ice-contact deposits. The ice chunks subsequently melted, leaving ponds in holes in the ground, with no hydrologic inlets or outlets. Over millennia, peat has progressively filled in the kettle holes from the edges inward toward the pond center; most still have a central bog pond with a floating mat border, while some have filled the kettles entirely with peat, obscuring the former ponds under floating or grounded peat mats. These are oligotrophic peatlands, due both to very limited terrestrial runoff influence from their small watersheds and coarse, porous soils, and to the dominance of precipitation as the primary water source (pHs are generally 4.0 or lower). There is often a moat or lagg separating the peat mat from the surrounding upland, which is largely a result of increased decomposition due to elevated nutrient levels from upland runoff as well as periodic, seasonal drawdown of the water table. The vegetation is dominated by species indicative of oligotrophic conditions including scattered, stunted black spruce, numerous dwarf heath shrubs (leather-leaf, small cranberry, sheep laurel, bog laurel), "mud-bottoms" (wet, floating lawns dominated by low, turfy mats of the leafy liverwort *Cladopodiella fluitans*, which turns black and looks like mud from a distance), bladderworts, and white beak-rush. A typical community sequence from the upland border towards the center of the kettle hole is marshy moat (when present), tall shrub fen or black spruce swamp, followed by a dense leather-leaf - black spruce bog zone, then a floating, reddish-colored open moss carpet (*Sphagnum rubellum*) with extremely dwarfed shrubs, and patches of *Sphagnum* pools with *Sphagnum cuspidatum* and mud-bottoms. With the exception of the zone immediately along the upland border, pHs are usually 4.0 or lower throughout the bog.

Diagnostic natural communities:

- Liverwort/horned bladderwort mud-bottom (S3)
- *Sphagnum rubellum* - small cranberry moss carpet (S3)
- Leather-leaf - black spruce bog (S3)
- Highbush blueberry - mountain holly wooded fen (S3S4)
- Marshy moat (S4)

Peripheral or occasional natural communities:

- Large cranberry - short sedge moss lawn (S3) (*Sphagnum cuspidatum* variant)
- Water willow - *Sphagnum* lagg (S3)
- Leather-leaf - sheep laurel dwarf shrub bog (S1S3)

Associated natural community systems: Kettle hole bog systems often occur in isolation of other wetland systems. They can also be surrounded by peat swamp systems (temperate, coastal conifer, or black spruce types) or occur adjacent to poor level fen/bog systems and, less frequently, medium level fen systems.

Characteristic species:

Indicators of oligotrophic conditions found in kettle hole and poor level fen/bog systems:

<u>Dwarf to short shrubs</u>

Chamaedaphne calyculata (leatherleaf) - < 20" high (max 36")

Kalmia angustifolia (sheep laurel)

Kalmia polifolia (bog laurel)

Andromeda polifolia var. *glaucophylla* (bog rosemary)

Ledum groenlandicum (Labrador tea)

Vaccinium oxycoccos (small cranberry)

Gaylussacia baccata (black huckleberry)

Gaylussacia dumosa (dwarf huckleberry)*

<u>Herbs and carnivorous plants</u>

Drosera rotundifolia (round-leaved sundew)

Drosera intermedia (spatulate-leaved sundew)

Sarracenia purpurea (pitcherplant)

Eriophorum virginicum (tawny cotton-grass)

Eriophorum vaginatum (hare's-tail)

Carex trisperma var. *billingsii* (Billing's sedge)

<u>Trees and tall shrubs</u> (sparse and dwarfed)

Vaccinium corymbosum (highbush blueberry)

Picea mariana (black spruce)

pHs generally 4.1 or lower

Mud bottoms with mats of black liverwort

Indicators of weakly to moderately minertrophic conditions **mostly absent** (or limited to peatland margins) in kettle hole and poor level fen/bogs:

<u>Herbs</u>

Carex lasiocarpa (hairy-fruited sedge)

Carex utriculata (bottle-shaped sedge)

Carex stricta (tussock sedge)

Carex lacustris (lake sedge)

Carex canescens (silvery sedge)

Lysimachia terrestris (swamp candles)

Dulichium arundinaceum (three-way sedge)

Triadenum virginicum (marsh St. John's-wort)

Osmunda cinnamomea (cinnamon fern)

<u>Shrubs and trees</u>

Myrica gale (sweet gale)

Spiraea alba (eastern meadowsweet)

Spiraea tomentosa (steeple bush)

Chamaedaphne calyculata (leatherleaf) – > 20" and usually closer to 36" high

Vaccinium macrocarpon (large cranberry)

Alnus incana ssp. *rugosa* (speckled alder)

Ilex verticillata (winterberry)

Acer rubrum (red maple)

pHs generally in low 4s to low 5s

• Poor level fen/bog system

Landscape settings: closed or stagnant, open headwater basins with limited drainage, often in depressions in glacial outwash or ice-contact deposits or broad lake basins away from the influence of lake water

Soils: deep, poorly decomposed peat oligotrophic, pHs generally $\leq$ 4.1; topogenous (limited limnogenous and soligenous influence)

Spatial pattern: small to large patch (5 - 100+ acres), occasionally extensive; circular to irregular shaped; more or less concentric zonation, less often irregular zonation; often with outlet stream, but without inlet streams

Physiognomy: sparse woodland, tall shrub, dwarf shrub, moss carpets/lawns

Distribution: broadly distributed; largest examples in central and northern New Hampshire

Description: Poor level fen/bogs are open, extremely acidic peatlands with only a limited amount of minerotrophic influence from the surrounding uplands, and very little or no groundwater or lake and stream influence. Oligotrophic to weakly minerotrophic conditions prevail, with pHs ranging from the high 3s to low 4s. They occur in a variety of landscape settings, ranging from nearly closed-basins to broad drainageways with sluggish, meandering streams, and adjacent to lakes but away from the influence of the lake-water. They are most frequent in areas of glacial outwash or ice-contact deposits. Peat is generally quite deep and poorly decomposed in the upper layers, with a well-developed hummock - hollow topography.

Most of the peatland area is dominated by species indicative of oligotrophic to, at most, weakly minerotrophic conditions including scattered, stunted black spruce, and extensive areas of mostly dwarfed heath shrubs (<0.5 m; leather-leaf, small cranberry, sheep laurel, bog laurel). A typical community sequence from the upland border towards the center of the peatland is a tall shrub fen or black spruce swamp border, followed by a dense leather-leaf - black spruce bog zone, then a reddish open moss carpet (*Sphagnum rubellum*) with extremely dwarfed shrubs, and occasionally patches of *Sphagnum* pools or lawns with *Sphagnum cuspidatum* or other aquatic peat mosses. There is sometimes a wet moat or lagg separating the peat mat from the surrounding upland. This develops from a combination of elevated nutrient levels in upland runoff and the periodic seasonal draw-down of the water table that increases the decomposition of the peat mat at the peatland margin. If a moat is not present, the outer zone is usually dominated by a peat swamp or a tall shrub fen (most commonly ***highbush blueberry - mountain holly wooded fen***). With the exception of the zone immediately along the upland border, pHs are usually in the low 4s or lower throughout the peatland. Floristic differences are evident in northern or higher elevation examples compared to coastal or southern examples, but the overall vegetation patterns are similar.

Diagnostic natural communities:

- *Sphagnum rubellum* - small cranberry moss carpet (S3)
- Leather-leaf - black spruce bog (S3)

- Leather-leaf - sheep laurel dwarf shrub bog (S1S3)
- Highbush blueberry - mountain holly wooded fen (S3S4)

Peripheral or occasional natural communities:

- Large cranberry - short sedge moss lawn (S3)
- Marshy moat (S4))
- Water willow - *Sphagnum* lagg (S3)

Associated natural community systems: This system can co-occur in large peatland basins with medium level fen and peat swamp systems (e.g., black spruce, coastal conifer, or temperate peat swamps). It is common for poor level fen/bogs to have small marginal areas adjacent to water bodies or uplands that have more minerotrophic communities typical of medium fens. When these areas are limited in extent or constitute a small proportion of the peatland, they are considered inclusions within the poor level fen/bog; when they are more extensive or constitute a substantial proportion of the peatland, the peatland may best be treated as having both poor and medium level fens systems within the same wetland. Conversely, medium level fens can have areas with more limited minerotrophic influence with poor fen communities. These are treated in the same way.

Characteristic species:

<u>Dwarf to short shrubs</u>

Chamaedaphne calyculata (leatherleaf) - < 20" high (max 36")

Kalmia angustifolia (sheep laurel)

Kalmia polifolia (bog laurel)

Andromeda polifolia var. *glaucophylla* (bog rosemary)

Ledum groenlandicum (Labrador tea)

Vaccinium oxycoccos (small cranberry)

Gaylussacia baccata (black huckleberry)

Gaylussacia dumosa (dwarf huckleberry)*

<u>Herbs and carnivorous plants</u>

Drosera rotundifolia (round-leaved sundew)

Drosera intermedia (spatulate-leaved sundew)

Sarracenia purpurea (pitcherplant)

Eriophorum virginicum (tawny cotton-grass)

Eriophorum vaginatum (hare's-tail)

Carex trisperma var. *billingsii* (Billing's sedge)

<u>Trees and tall shrubs</u> (sparse and dwarfed)

Vaccinium corymbosum (highbush blueberry)

Picea mariana (black spruce)

pHs generally 4.1 or lower

Refer also kettle hole bog system for list of minerotrophic indicators absent from poor level fen/bog systems.

• Medium level fen system

Landscape settings: sluggish stream, pond or lake borders, open headwater basins, drained depressions in glacial outwash or ice-contact deposits

Soils: deep, poorly- to moderately well-decomposed peat; weakly to moderately minerotrophic; pHs generally in low 4s to mid 5s; topogenous and limnogenous (limited soligenous influence)

Spatial pattern: small to large patch (5 - 100+ acres); irregularly circular or linear; irregular or banded zonation parallel to stream or pond border; streams often pass through peatland (has inlet and outlet)

Physiognomy: sparse woodland, tall shrub, medium-height shrub, moss carpets/lawns

Distribution: broadly distributed in New Hampshire

Description: Medium level fens are open, acidic peatlands with more minerotrophic influence than poor level fen/bogs due to the effects of upland runoff, exposure to lake and stream water, or limited groundwater seepage. Weakly to moderately minerotrophic conditions prevail, with pHs ranging from the low 4s to mid 5s. They occur in a variety of landscape settings, but mostly along stream and lake borders where the nutrient levels and seasonal fluctuations of water levels are greater than in poor level fens, but less than in emergent marshes (thus allowing peat to accumulate over the long term). They are most frequent around relatively stagnant ponds and lakes and drained depressions in glacial outwash or ice-contact deposits. Peat is moderate to deep and moderately well decomposed in the upper layers, with a well-developed hummock - hollow topography in many of its constituent communities. They are more common than kettle hole bog and poor level fen/bog systems.

These systems are a mosaic of open, sedge-dominated fens, dwarf to medium-height shrublands, and open moss lawns, carpets, and pools. Tall shrub fens are also common. In shrubby areas, vigorous patches of *Myrica gale* (sweet gale), *Spiraea alba* (eastern meadowsweet), and sometimes *Chamaedaphne calyculata* (leatherleaf) are prominent and usually more than 20" (50 cm) in height (leather-leaf tends to be shorter in poor level fen/bogs). *Ilex verticillata* (winterberry), *Toxicodendron vernix* (poison sumac), *Acer rubrum* (red maple), and *Larix laricina* (eastern larch or tamarack) indicate weakly to moderately minerotrophic conditions in areas that have tall shrubs and trees (these species are sparse or absent in poor fens). Robust, tall sedges, like *Carex lasiocarpa* (hairy-fruited sedge), *Carex utriculata* (bottle-shaped sedge), and *Carex stricta* (tussock sedge), are also common, and may dominate large areas individually or in mixtures with other species. Lagg (moat) areas along the upland margin and lawns, carpets, and pools near water bodies often support aquatic peat mosses and herbs such as *Sphagnum torreyanum*, *S. cuspidatum*, *S. pulchrum*, *Carex canescens* (silvery sedge), *Vaccinium macrocarpon* (large cranberry), *Rhynchospora alba* (white beak-rush), and *Dulichium arundinaceum* (three-way sedge).

A typical natural community sequence from the upland border towards the center of the basin, channel, or water-margin is as follows: a moat or lagg zone; a tall shrub fen zone; a dense medium-height shrub zone with sweet gale; sedge fen; and open moss carpet areas closest to the water's edge. Moss carpets or lawns are typically not present or well developed in fens along streams, but are more common in lake border or floating mat settings.

Diagnostic natural communities:

Moss lawns and sedge/medium-shrub fens

- Sweet gale - meadowsweet - tussock sedge fen (S4)
- Hairy-fruited sedge - sweet gale fen (S3)
- Large cranberry - short sedge moss lawn (S3)
- Bog rosemary - sweet gale - sedge fen (S3)

Tall shrub fens

- Highbush blueberry - sweet gale - meadowsweet shrub thicket (S4)
- Winterberry - cinnamon fern wooded fen (S4)
- Sweet pepperbush wooded fen (S2)
- Speckled alder wooded fen (S3S4)

Peripheral or occasional natural communities:

- Floating marshy peat mat (S3S4)
- Marshy moat (S4)
- Water willow - *Sphagnum* lagg (S3)
- Speckled alder - lake sedge intermediate fen (S2S3)

Associated natural community systems: This system can co-occur in large peatland basins with poor level fen/bogs. It is typical for medium level fens to have small portions of the peatland dominated by oligotrophic conditions and communities. When these areas are limited in extent or constitute a small proportion of the wetland, they are considered inclusions within the medium level fen system; when they are more extensive or constitute a substantial proportion of the peatland, the peatland may best be treated as having both poor and medium level fens systems within the same wetland site. Conversely, poor level fen/bogs can have areas with more minerotrophic influence with medium level fen communities. These are treated in the same way.

Characteristic species:

Indicators of weakly to moderately minertrophic conditions found in medium level fens (mostly absent or limited to marginal areas of kettle hole and poor level fen/bogs):

Herbs

Carex lasiocarpa (hairy-fruited sedge)

Carex utriculata (bottle-shaped sedge)

Carex stricta (tussock sedge)

Carex lacustris (lake sedge)

Carex canescens (silvery sedge)

Lysimachia terrestris (swamp candles)

Dulichium arundinaceum (three-way sedge)

Triadenum virginicum (marsh St. John's-wort)

Osmunda cinnamomea (cinnamon fern)

Shrubs and trees

Myrica gale (sweet gale)

Spiraea alba (eastern meadowsweet)

Spiraea tomentosa (steeple bush)

Chamaedaphne calyculata (leatherleaf) - > 20" and usually closer to 36" high

Vaccinium macrocarpon (large cranberry)

Ilex verticillata (winterberry)

Alnus incana ssp. *rugosa* (speckled alder)

Acer rubrum (red maple)

Larix laricina (eastern larch)

Toxicodendron vernix (poison sumac

pHs generally in low 4s to low 5s

Many species of kettle hole and poor level fen/bog systems may also be found in medium level fens (see list in kettle hole bog system)

• Montane sloping fen system

Landscape settings: moderate- to high-elevation (above 2400 ft.) valley bottoms and adjacent gently sloped mountain side-slopes; occur on definite soligenous slopes, shallow level depressions, and small drainage-ways associated with old beaver dams

Soils: shallow, well-decomposed peat; often on glacial lake bed or other silty-gravelly mineral deposits; weakly to moderately minerotrophic; pHs average 5.3 (4.2 to 6.3); soligenous and topogenous

Spatial pattern: small to large patch (<5 - 50+ acres); oval to irregularly amoeboid or linear shapes, irregular zonation

Physiognomy: graminoid - moss lawns, graminoid - shrub, tall shrub, sparse woodland and woodland

Distribution: found above 2400 ft. in the White Mountains

Description: This peatland system is weakly to moderately minerotrophic and forms nearly level to demonstrably sloping soligenous peat mats in the White Mountains at moderate to high elevations (above 2400 ft.). Slopes are frequently up to 10 degrees, with a maximum of about 20 degrees. This system consists sloping to nearly level, open graminoid and graminoid – shrub fen communities that occur in a mosaic with ***montane alder – heath shrub thickets*** and ***montane heath woodlands***. These three communities (respectively) range from very poorly drained, shallow peat over cryic, silty gravel, to somewhat poorly drained shallow peat over bedrock or silty gravel. Peats are well decomposed, and hummock - hollow topography is moderately well to poorly developed. pHs range from 4.2 to 6.2 (average 5.3). Portions of some montane sloping fen systems are associated with headwater drainage areas formerly impounded by beavers that were abandoned decades ago and have subsequently filled in with organics.

The key diagnostic natural community of this system, montane sloping fen, is dominated by graminoids or graminoids and shrubs, and is the only known fen in the state or region that is dominated by a grass. *Calamagrostis pickeringii* (Pickering's reed bent-grass) on average contributes about 5% cover, and *Carex wiegandii* (Wiegand's sedge) is frequent (both are state and regionally rare). Numerous other northern poor and medium fen plants are present (listed below).

Diagnostic natural communities:

- Montane sloping fen (S1)
- Montane alder - heath shrub thicket (S1?)
- Montane heath woodland (S2)

Associated natural community systems: These systems are often set in a matrix of spruce - fir forest/swamp systems in high-elevation valley bottoms, which sometimes include montane black spruce - red spruce forests.

Characteristic species:

Montane sloping fen:

Herbs

Calamagrostis pickeringii (Pickering's bluejoint)*

Carex wiegandii (Wiegand's sedge)*

Carex echinata (prickly sedge)

Carex pauciflora (few-flowered sedge)

Carex oligosperma (few seeded sedge)

Solidago purshii (Pursh's goldenrod)

Veratrum viride (false hellebore)

Platanthera clavellata (small green woodland orchid)

Drosera rotundifolia (round-leaved sundew)

Eriophorum virginicum (tawny cotton-grass)

Shrubs

Chamaedaphne calyculata (leather-leaf)

Kalmia polifolia (bog laurel)

Ledum groenlandicum (Labrador-tea)

Rhododendron canadense (rhodora)

Nemopanthus mucronatus (mountain holly)

Lowland peatland plants are absent, including:

Vaccinium corymbosum (highbush blueberry)

Gaylussacia baccata (black huckleberry)

Ilex verticillata (winterberry)

Woodwardia virginica (Virginia chain fern)

• Patterned fen system

Hydrogeomorphic categories: palustrine, depressional, gently sloping, peatland,

Landscape settings: extensive flats (peatland and lowland spruce - fir forest/swamps)

Soils: moderately well to well decomposed peat; weakly minerotrophic (acidic examples) to strongly minerotrophic (circumneutral to alkaline examples); pHs 4-5 (acidic examples); 6.3 - 8.0 (circumneutral to alkaline examples); soligenous with some topogenous influence

Spatial pattern: small to large patch (15 - 50+ ac); oblong to broad ovals; repeating parallel (or anastamosing) zonation of strings (hummock ridges) and flarks (hollows)

Physiognomy: dwarf shrub with stunted conifers, graminoid - moss carpets

Distribution: found only in extreme northern New Hampshire

Description: Slow groundwater movement through broad gently sloped peatlands forms a series of linear hummock ridges, called strings, separated by parallel hollows known as flarks. Strings and flarks are arranged perpendicularly to the flow of water through the peatland and can form a regular pattern of parallel ridges and hollows or an intricate, anastamosing pattern. Acidic patterned fens occur where groundwater seepage is nutrient-poor. Patterned peatlands reach their southern extent in New Hampshire where patterning is less well developed than further north; they are more extensive and well-developed in boreal and subpolar areas where precipitation greatly exceeds evaporation.

The strings and flarks in these patterned peatlands have dramatically different vegetation. The strings in acidic examples are similar to poor level fen/bog vegetation and primarily composed of dwarf shrub vegetation, dominated by leather-leaf, other dwarf shrubs, and scattered, stunted black spruce and eastern larch. Herbs are sparse on these hummock ridges. Hollows are filled with open pools, liverwort/horned bladderwort mud-bottoms, or *Sphagnum* moss carpets with sparse dwarf shrubs and sundews. *Carex exilis* (meagre sedge)* is a diagnostic herb of flarks in New Hampshire patterned fens.

The strings in our one circumneutral example are primarily dominated by stunted (and heavily browsed) northern white cedar, averaging 1 m tall amidst dwarf shrubs, with a taller scattered canopy of northern white cedar, black spruce, eastern larch, and red maple. Herbs are scattered in low abundance. All of this is over a diverse carpet of peat mosses and "brown" mosses (mostly in Amblestigeacae family). The circumneutral flarks range from a few meters to more than 10 m wide and have a thick mat of brown algae interspersed with low plant cover of herbs and mosses.

While the distinct vegetative differences between acidic and circumneutral examples could support splitting this system into two types, we consider them together as one type for purely pragmatic conservation reasons: there are so few examples, all have high conservation value, and none are likely to be overlooked in conservation efforts.

Diagnostic natural communities:

<u>Flarks</u>

- Liverwort/horned bladderwort mud-bottom (S3)

- *Sphagnum rubellum* - small cranberry moss carpet (S3)
- Large cranberry - short sedge moss lawn (S3) (*S. cuspidatum* variant)
- Circumneutral - calcareous flark (S1) (circumneutral examples)

Strings

- Leather-leaf - black spruce bog (S3)
- Northern white cedar circumneutral string (S1)

Associated systems: Patterned fens are surrounded by black spruce peat swamp and lowland spruce - fir forest/swamp systems (acidic examples) and northern white cedar minerotrophic swamp system (circumneutral example).

Characteristic species:

Strings:

Acidic strings:
Picea mariana (black spruce)
Larix laricina (eastern larch)
Chamaedaphne calyculata (leatherleaf)
Kalmia angustifolia (sheep laurel)
Ledum groenlandicum (Labrador tea)

Northern white cedar circumneutral string

Thuja occidentalis (northern white cedar) – dom.
Picea mariana (black spruce)
Larix laricina (eastern larch)
Chamaedaphne calyculata (leatherleaf)
Kalmia angustifolia (sheep laurel)
Ledum groenlandicum (Labrador tea)
Muhlenbergia glomerata (clustered marsh muhly)
Trichophorum alpinum (northern cotton club rush)
Salix pedicellaris (bog willow)

Flarks:

Acidic flarks:
Cladopodiella fluitans (liverwort)
Utricularia cornuta (horned bladderwort)
Vaccinium oxycoccos (small cranberry)
Drosera rotundifolia (round-leaved sundew)
Drosera intermedia (spatulate-leaved sundew)
Carex exilis (meagre sedge)*
Sphagnum rubellum (peat moss)
Sphagnum cuspidatum (peat moss)

Circumneutral – calcareous flark:

Sphagnum contortum (peat moss)*
Carex exilis (meagre sedge)*
Menyanthes trifoliata (buckbean)
Trichophorum alpinum (cotton club rush)
Utricularia minor (small bladderwort)
Sarracenia purpurea (pitcherplant)
Rhynchospora alba (white beak-rush)
Drosera intermedia (spatulate-leaved sundew)
Carex livida (livid sedge)*
Juncus stygius var. *americanus* (moor rush)*
Carex tenuiflora (thin-flowered sedge)*
Muhlenbergia glomerata (clustered muhly)

• Calcareous sloping fen system

Landscape settings: headwater positions, openings in northern white cedar swamps, steep terraces of rivers or streams, hill side slopes; also in small basins or catchments, stream margins, and old pastures

Soils: well decomposed shallow to moderately deep peat; strongly minerotrophic; pH ranges from 6.7 to 8.2 (average 7.2); soligenous

Spatial pattern: small patch (mostly <5 acres); irregular zonation or uniform

Physiognomy: graminoid - moss carpets, sedge - medium height shrub

Distribution: north and northwest of the White Mountains and northern Connecticut River valley

Description: Calcareous fens are dominated by a unique assemblage of low sedges and other graminoids over a carpet of "brown" mosses and several uncommon to rare peat mosses. Scattered willow and dogwood shrubs are often present. These peatlands are among the most botanically diverse in New Hampshire and contain many calciphilic plant species in addition to more common wetland species. There are often numerous orchids and other unique herbs interspersed among the graminoids and shrubs, which are also absent in oligotrophic to moderately minerotrophic peatland systems such as medium and poor level fen/bogs and kettle hole bogs. Many of these species are rare, and restricted to these systems.

These systems are restricted to areas that have considerable year-round seepage through base-rich or carbonate-bearing bedrock types. Minerotrophic seepage is the primary water source in these systems and there are often rivulets or small open pools. These systems are small in size and occur in a variety of settings in New Hampshire including both groundwater influenced and "disturbed" areas, such as old pastures. Common settings for this system include headwater positions, open gaps in calcareous seepage swamps (e.g. northern white cedar swamps), step terraces of rivers or streams, and side slopes of hills. They also occur in small basins, kettles, or catchments with seepage influence and along margins of streams flowing through marshes or swamps in areas with calcareous bedrock. Certain expressions of these systems often occur where disturbance maintains vegetation in an early successional state, such as beaver meadows and grazed pastures or hay fields.

Soils typically are comprised of shallow to moderate depths of well-decomposed peat. Peat depth varies with landscape setting; deeper peat accumulation occurs in basins and gentle slopes relative to steeper slopes or periodically disturbed areas such as terraces along major rivers or old pastures. While some examples are nearly level, most have gentle to prominent slopes.

Diagnostic natural communities:

- Calcareous sedge - moss fen (S2)

Associated natural community systems: This system is most often associated with northern white cedar minerotrophic swamp systems, and occasionally emergent marsh - shrub swamp or spruce - fir forest/swamp systems.

Characteristic species:

Calcareous sedge – moss fen:

Trees and shrubs

Cornus sericea (red osier dogwood)

Pentaphylloides floribunda (shrubby cinquefoil)

Thuja occidentalis (northern white cedar)

Herbs

Carex interior (inland sedge)

Carex flava (yellow sedge)

Carex hystericina (porcupine sedge)

Carex aurea (golden-fruited sedge)*

Carex castanea (chestnut sedge)*

Trichophorum cespitosum (northern cotton club rush)

Senecio schweinitzianus (New England groundsel, Robbins' ragwort)

Lobelia kalmii (Kalm's lobelia)*

Parnassia glauca (grass-of-parnassus)*

Petasites frigidus var. *palmatus* (sweet coltsfoot)*

Cypripedium reginae (showy lady's slipper)*

Bryophytes

Aulocomnium palustre (moss)

Philonotus fontana (moss)

Sphagnum warnstorfii (peat moss)

Tomenthypnum nitens (moss)

Bryum pseudotriquetrum (moss)

Campyllium stellatum (moss)

Pellia epiphylla (liverwort)

• Black spruce peat swamp system

Landscape settings: closed or stagnant, open headwater basins with limited drainage, often in depressions in glacial outwash or ice-contact deposits or broad lake basins away from the influence of lake water

Soils: deep, moderately well decomposed peat; oligotrophic to weakly minerotrophic; pHs generally in 3s to mid 4s, occasionally higher; topogenous

Spatial pattern: small to large patch (5 - 100+ acres), occasionally extensive; circular to irregular shape, often as exterior zone around open peatlands or uniform, sometimes in mosaics with more open peatlands;

Physiognomy: forest to woodland and tall shrub

Distribution: broadly distributed in central and northern New Hampshire, much less common in lowland southern New Hampshire

Description: This system corresponds to acidic, nutrient-poor wooded peatlands dominated by boreal conifers and heath shrubs, particularly *Picea mariana* (black spruce) and to a lesser extent *Larix laricina* (eastern larch) and other conifers. The main community is ***black spruce – larch swamp***, which has a transcontinental boreal distribution with extensions south into northern and central New Hampshire. This community often surrounds open peatlands or can dominate peatland basins that have no open peatlands. This system occurs on moderately to very deep peats. Black spruce dominated areas on peat sometimes transitions to ***acidic northern white cedar swamps*** on peat or ***red spruce swamps*** on mineral soil, or ***northern white cedar – balsam fir swamp*** on minerotrophic peats. These are acidic peatlands, typically with pHs in the high 3s to mid-4s, but occasionally higher in weakly minerotrophic swamps where eastern larch is in greater abundance. Patches of tall shrub peatland thickets (fens with <25% tree cover) are common as part of the swamp mosaic. Where these tall shrub fens become extensive, they may be best considered part of an adjacent open peatland system.

Diagnostic natural communities:

- Black spruce - larch swamp (S3)
- Acidic northern white cedar swamp (S1)
- Highbush blueberry - mountain holly wooded fen (S3S4)
- Speckled alder wooded fen (S3S4)

Peripheral or occasional natural communities:

- Red spruce swamp (S3)
- Northern white cedar - balsam fir swamp (S2)

Associated natural community systems: This system is often found in association with poor level fen/bogs, kettle hole bogs, and lowland spruce - fir forest/swamp systems. When this system surrounds an open bog or fen system, the two communities that typically mark the transition to open peatland system are ***leather-leaf - black spruce bog*** and ***highbush blueberry - mountain holly wooded fen***. The frequency and size of this system generally diminishes to the south in New Hampshire where temperate or coastal conifer peat systems are more common, and where black spruce swamps usually form narrow borders around bogs.

Characteristic species:

Black spruce - larch swamp:

Trees and shrubs
Picea mariana (black spruce) – dominant
Occasional to locally abundant:
Larix laricina (eastern larch)
Picea rubens (red spruce)
Abies balsamea (balsam fir)
Nemopanthus mucronatus (mountain holly)
Viburnum nudum var. *cassinoides* (witherod)
Lyonia ligustrina (male berry)

Dwarf shrubs
Ledum groenlandicum (Labrador tea)
Kalmia angustifolia (sheep laurel)
Rhododendron canadense (rhodora)
Vaccinium myrtilloides (velvet-leaf blueberry)
Gaultheria hispidula (creeping snowberry)
Cornus canadensis (bunchberry)
Coptis trifolia (goldthread)

Herbs
Carex trisperma var. *trisperma* (three-seeded sedge)
Osmunda cinnamomea (cinnamon fern)

Bryophytes
Sphagnum spp. (peat mosses)

• Coastal conifer peat swamp system

Landscape settings: stagnant, closed or open headwater basins with limited drainage; often in depressions in glacial outwash or ice-contact deposits or broad lake basins away from the influence of lake water

Soils: deep, moderately well decomposed peat; oligotrophic to weakly minerotrophic; pHs generally less than 5, occasionally higher; topogenous

Spatial pattern: small to large patch (<5 - 30+ acres); circular to irregular shape; uniform or forming exterior zone around open peatlands, sometimes in mosaics with more open peatlands

Physiognomy: forest to woodland with tall shrub patches

Distribution: found in coastal New Hampshire with disjuncts in the highlands of southwest New Hampshire, in the Merrimack Valley and the Lakes Region

Description: This system corresponds to acidic, oligotrophic peatlands in central and southern New Hampshire dominated by *Chamaecyparis thyoides* (Atlantic white cedar), and occasionally *Pinus rigida* (pitch pine). The system is characterized by one or more of the five Atlantic white cedar natural communities. Atlantic white cedar dominates some or all of a peatland basin, mixing in some areas with ***red maple – Sphagnum basin swamps*** and tall shrub fen communities. It is found in association with and in isolation of open peatland systems. This system occurs on moderately to very deep peat with pHs less than 5, although pH and trophic levels can be higher around the system margins where there is a shift in natural community type. Some inland examples of this system are very acidic (pHs as low as 3.4); seasonally flooded portions of these systems that transition to emergent marshes have higher pHs (4.4 to 6.5). Coastal plain and southern species are more common in this wetland system than in more inland, northern, or higher elevation temperate peat swamps. These include *Clethra alnifolia* (sweet pepperbush), *Rhododendron maximum* (giant rhododendron)*, and *Sphagnum flavicomans* (peat moss). Patches of tall shrub peatland thickets (fens with <25% tree cover) are common as part of the swamp mosaic. Where these tall shrub fens become extensive, they may be best considered part of an adjacent open peatland system.

Diagnostic natural communities:

- Atlantic white cedar - yellow birch - pepperbush swamp (S2)
- Inland Atlantic white cedar swamp (S1)
- Atlantic white cedar - leather-leaf swamp (S1)
- Atlantic white cedar - giant rhododendron swamp (S1)
- Seasonally flooded Atlantic white cedar swamp (S2)
- Pitch pine - heath swamp (S1S2)
- Sweet pepperbush wooded fen (S2)
- Highbush blueberry - mountain holly wooded fen (S3S4)
- Red maple - *Sphagnum* basin swamp (S4)

Peripheral or occasional natural communities:

- Black gum - red maple basin swamp (S1S2)
- Highbush blueberry - winterberry shrub thicket (S4)

Associated natural community systems: This system is often found in association with poor level fen/bogs, kettle hole bogs, and in stagnant headwater basins in isolation of other peatlands or open wetlands. It is most similar to the temperate peat swamp system, which is largely hardwood dominated, more common, and ranges further northward, inland, and to higher elevations.

Characteristic species:

Trees

Abundant

Chamaecyparis thyoides (Atlantic white cedar)

Acer rubrum (red maple)

Frequent:

Betula alleghaniensis (yellow birch)

Tsuga canadensis (hemlock)

Picea rubens (red spruce)

Shrubs

Ilex verticillata (winterberry)

Vaccinium corymbosum (highbush blueberry)

Nemopanthus mucronatus (mountain holly)

Clethra alnifolia (sweet pepperbush)

Rhododendron maximum (giant rhododendron)*

Kalmia latifolia (mountain laurel)

Kalmia angustifolia (sheep laurel)

Herbs

Osmunda cinnamomea (cinnamon fern)

Coptis trifolia (goldthread)

Mitchella repens (partridgeberry)

Osmunda regalis var. *spectabilis* (royal fern)

Carex trisperma var. *trisperma* (three-seeded sedge)

Thelypteris simulata (Massachusetts fern)

• Temperate peat swamp system

Landscape settings: closed or stagnant, open headwater basins with limited drainage, often in depressions in glacial outwash or ice-contact deposits or lake or pond basins away from the influence of lake water

Soils: deep, moderately well decomposed peat; oligotrophic to weakly minerotrophic; pHs generally less than 5; topogenous

Spatial pattern: small to large patch (<5 - 50+ acres), circular to irregular shape; uniform or forming exterior zone around open peatlands, sometimes in mosaics with more open peatlands

Physiognomy: forest to woodland with tall shrub patches

Distribution: found in central and southern New Hampshire

Description: This system corresponds to acidic, oligotrophic peatlands in central and southern New Hampshire dominated by *Acer rubrum* (red maple) with variable amounts of conifers and other hardwoods. *Picea rubens* (red spruce) as a common but minor associate, but otherwise northern conifers are absent or sparse, particularly in southern New Hampshire. The tall shrub layer is well developed and dominated by the ubiquitous *Vaccinium corymbosum* (highbush blueberry) and *Ilex verticillata* (winterberry). An abundance of peat mosses (*Sphagnum* spp.), *Osmunda cinnamomea* (cinnamon fern), and other herbs are characteristic. It is characterized by oligotrophic to weakly minerotrophic conditions, and therefore lacks minerotrophic indicators (although sometimes found around the margins) indicative of temperate minerotrophic swamps, such as *Onoclea sensibilis* (sensitive fern), *Toxicodendron radicans* (climbing poison ivy), *Lindera benzoin* (northern spicebush), and *Fraxinus nigra* (black ash). The core community is ***red maple – Sphagnum basin swamp***, which is usually a peatland (>40 cm organic matter) but sometimes occurs on mineral soils with a histic epipedon (shallow organic layer less than 40 cm) where there may be more seasonal water fluctuations than in deep peat settings. Mineral histic examples may occupy the entire swamp basin, or more commonly just the swamp areas marginal to uplands where organic accumulation is less. The system is sometimes found in association with open peatland systems, but may also occur by itself. Measured pHs are generally less than 5.3 (as low as 3.7), although pH and trophic levels can be higher around the system margins where there is often a shift in natural community type. More southern or low elevation examples are more likely to contain species restricted to coastal or southern parts of the state. Patches of tall shrub fens (<25% tree cover) are common as part of the swamp mosaic; where these tall shrub fens become extensive, they may be best considered part of an adjacent open peatland system. The transition to upland forests in this swamp system is often marked by a border of ***hemlock – cinnamon fern forest*** or ***red maple – red oak – cinnamon fern forest***.

Diagnostic natural communities:

- Red maple - *Sphagnum* basin swamp (S4)
- Black gum - red maple basin swamp (S1S2)
- Swamp white oak basin swamp (S1)
- Highbush blueberry - winterberry shrub thicket (S4)

- Highbush blueberry - mountain holly wooded fen (S3S4)
- Winterberry - cinnamon fern wooded fen (S4)

Peripheral or occasional natural communities:

- Hemlock - cinnamon fern forest (S4)
- Red maple - red oak - cinnamon fern forest (S3S4)
- Red maple - sensitive fern swamp (S3S4)
- Seasonally flooded red maple swamp (S4S5)
- Red spruce swamp (S3)

Associated natural community systems: This swamp system may be found around some poor level fen/bog and kettle hole bog systems, and in association with coastal conifer peat or temperate minerotrophic swamp systems, particularly in larger swamp systems that encompass a broad range of wetland conditions. This system transitions to red spruce swamps at moderate elevations.

Characteristic species:

Trees and shrubs

Abundant species:

Acer rubrum (red maple)

Vaccinium corymbosum (highbush blueberry)

Ilex verticillata (winterberry)

Occasional to locally abundant species (broad distribution):

Picea rubens (red spruce)

Tsuga canadensis (hemlock)

Betula alleghaniensis (yellow birch)

Nemopanthus mucronatus (mountain holly)

Kalmia angustifolia (sheep laurel)

Occasional to locally abundant species (restricted to coastal or southern NH; absent from near-boreal swamps):

Nyssa sylvatica (black gum)

Quercus bicolor (swamp white oak)

Clethra alnifolia (sweet pepperbush)

Ilex laevigata (smooth winterberry)

Rhododendron viscosum (swamp azalea)

Rhododendron maximum (giant rhododendron)

Kalmia latifolia (mountain laurel)

Herbs and bryophytes

Abundant:

Osmunda cinnamomea (cinnamon fern)

Sphagnum spp. (peat mosses)

Occasional to locally abundant (broad distribution):

Carex trisperma var. *trisperma* (three-seeded sedge)

Thelypteris palustris (marsh fern)

Lycopus uniflorus (common water horehound)

Carex folliculata (follicled sedge)

Carex canescens ssp. *canescens* (silvery sedge)

Occasional to locally abundant (coastal or southern distribution):

Thelypteris simulata (Massachusetts fern)

Woodwardia virginica (Virginia chain fern)

Woodwardia aereolata (netted chain fern)

Sphagnum torreyanum (peat moss)

• Near-boreal minerotrophic peat swamp system

Landscape settings: headwater basins and broad drainageways, extensive flats, pond and lake basins, and adjacent gentle slopes

Soils: deep to moderately deep, well-decomposed peat, grading to mineral soils in sloped swamp margins; moderately to strongly minerotrophic, pHs range from 4.9 – 7.5; topogenous and soligenous

Spatial pattern: small to large patches (<5 – 100+ acres), sometimes extensive; circular-oval or irregular shape; uniform or sometimes with sedgy or shrubby openings or surrounding open peatlands

Physiognomy: forest to woodland with tall shrub or herbaceous openings

Distribution: occurs north and northwest of the White Mountains; disjunct in Conway area

Description: This system is primarily found in the North Country on deep, minerotrophic organic soils with *Thuja occidentalis* (northern white cedar). At least two swamp types are typically present: ***northern white cedar – balsam fir swamps*** tend to occur on organic soils (muck and peat > 16 in.); and ***northern hardwood – black ash - conifer swamps*** are often found toward the swamp margins on level to sloping mineral soil (shallow organic layer 0-16 in.). In contrast to more acidic black spruce peat swamps, this swamp system is strongly influenced by minerotrophic groundwater seepage. Overall the swamps are conifer-dominated or conifer and mixed hardwood – conifer dominated. Abundant to frequent northern conifers and hardwoods includes northern white cedar, *Abies balsamea* (balsam fir), *Larix laricina* (eastern larch), and *Picea* spp. (spruces); *Fraxinus nigra* (black ash), *Betula alleghaniensis* (yellow birch), and *Acer rubrum* (red maple). Northern white cedar swamps have a northeastern-boreal distribution in North America (Great Lakes to Canadian Maritimes), and extend into northern New Hampshire, mostly north of the White Mountains. Black ash is more broadly distributed in eastern North America, but reaches its maximum abundance in New Hampshire in this system. These are diverse swamp systems that harbor many vascular plants (>200 species) and bryophytes (>65 species), particularly those preferring circumneutral conditions. The peat or muck in the ***northern white cedar – balsam fir swamps*** are usually over a meter in depth, well decomposed, and with an average pH of 6.1 (range of 4.9 – 7.5); soils in ***northern hardwood – black ash - conifer swamps*** consist of circumneutral to subacid (pH of 5.3 – 6.3), shallow, well decomposed muck over silty material. The sloping mineral soil margins can also transition to ***northern white cedar seepage forest***. There are a few cedar swamps south of the White Mountains, which contain the ***northern white cedar – hemlock swamp*** community. ***Alder wooded fens*** are often part of this system, and can mark the transition to open peatland systems or alder alluvial shrublands along large streams. Calcareous fen openings occur in a few swamps where calcareous groundwater discharge is prominent.

Diagnostic natural communities:

- Northern white cedar - balsam fir swamp (S2)
- Northern hardwood - black ash - conifer swamp (S2)
- Northern white cedar seepage forest (S2)

- Speckled alder wooded fen (S3S4)
- Seasonally flooded boreal swamp (SU)

Peripheral or occasional natural communities:

- Calcareous sedge - moss fen (S2)
- Acidic northern white cedar swamp (S1)
- Northern white cedar - hemlock swamp (S2)
- Black spruce – larch swamp (S3)
- Northern hardwood seepage forest (S3)

Associated natural community systems: Medium level and rich sloping fens are often associated with this swamp system, and in large wetland basins may co-occur with near-boreal hardwood - conifer minerotrophic swamp systems.

Characteristic species:

Northern white cedar – balsam fir swamp:

Trees

Abundant:

Thuja occidentalis (northern white cedar)

Abies balsamea (balsam fir)

Occasional species:

Fraxinus nigra (black ash)

Betula alleghaniensis (yellow birch)

Acer rubrum (red maple)

Picea spp. (spruces)

Dwarf shrubs and herbs

Carex trisperma var. *trisperma* (three-seeded sedge)

Osmunda cinnamomea (cinnamon fern)

Coptis trifolia (goldthread)

Rubus pubescens (dwarf raspberry)

Oxalis montana (northern wood sorrel)

Dalibarda repens (false violet)

Carex leptalea (delicate sedge)

Dryopteris cristata (crested wood fern)

Tiarella cordifolia (foamflower)

Bryophytes

Hylocomium splendens (moss)

Amblystegium riparium (moss)

Rhytidiadelphus triquetrus (moss)

Rhytidiadelphus subpinnatus (moss)

Thuidium delicatulum (moss)

Bazzania trilobata (liverwort)

Rhizomnium punctatum (moss)

Sphagnum girgensohnii (peat moss)

Sphagnum subtile (peat moss)

Sphagnum russowii (peat moss)

Characteristic species largely absent from other cedar swamp communities:

Mitella nuda (naked miterwort)

Carex pedunculata (long-stalked sedge)

Pyrola secunda (one-sided shinleaf)

Platanthera obtusata (blunt-leaved orchid)

Rhamnus alnifolia (American alder buckthorn)

Some potential rare species (***northern white cedar - balsam fir swamp***):

Petasites frigidus var. *palmatus* (sweet coltsfoot)*

Carex castanea (chestnut sedge)*

Cypripedium reginae (showy lady's slipper)*

Cypripedium parviflorum var. *pubescens* (large yellow lady's slipper)*

Cypripedium parviflorum var. *makasin* (yellow lady's slipper)*

Liparis loeselii (Loesel's twayblade)*

Northern hardwood – black ash - conifer swamps:

Trees

Abundant species:

Fraxinus nigra (black ash)

Betula alleghaniensis (yellow birch)

Abies balsamea (balsam fir)

Picea rubens (red spruce)

Frequent species:

Thuja occidentalis (northern white cedar)

Acer rubrum (red maple)

Picea glauca (white spruce)

Populus balsamifera (balsam poplar)

Fraxinus americana (white ash)

Northern hardwood – black ash - conifer swamps (cont):

Shrubs

Alnus incana ssp. *rugosa* (speckled alder)

Ilex verticillata (winterberry)

Viburnum nudum var. *cassinoides* (witherod)

Toxicodendron radicans (climbing poison ivy)

Lonicera canadensis (Canadian honeysuckle)

Herbs

Geum rivale (purple avens

Onoclea sensibilis (sensitive fern)

Impatiens capensis (spotted touch-me-not)

Tiarella cordifolia (foamflower)

Hydrocotyle americana (water pennywort)

Senecio schweinitzianus (New England groundsel, Robbins' ragwort)

Chrysosplenium americanum (golden saxifrage)

Carex gynandra (perfect-awned sedge)

Galium kamtschaticum (northern wild licorice)*

Bryophytes

Abundant (particularly the "Brown Mosses" and other non-Sphagnum mosses) but poorly documented

PRIMARILY MINERAL SOIL WETLANDS

These are non-riparian systems found in depressional or sloped settings or along drainages of small streams (i.e., first and second order). They lack forested floodplains or well developed, periodically exposed river or stream channel and bank communities that develop on larger streams and rivers (generally third order and higher).

WOODED SWAMPS (WEAKLY TO STRONGLY MINEROTROPHIC)

• Temperate minerotrophic swamp system

Landscape settings: depressional headwater basins and drainage ways; sloping mineral soils around open wetlands; pond and lake basins

Soils: mostly flat to moderately sloping mineral soils or shallow, well-decomposed peat or muck; moderately to strongly minerotrophic; pHs in the 5s and 6s; topogenous to soligenous, non-riparian

Spatial pattern: small to large patches (<5 – 50+ acres); circular-oval or irregular shaped; uniform, sometimes with shrubby openings or surrounding open wetlands

Physiognomy: forest to woodland with tall shrub openings

Distribution: widespread south of the White Mountains

Description: This is a relatively common red maple swamp system found in central and southern New Hampshire with well decomposed shallow peat or mineral soils, including classic seepage swamps and other more common minerotrophic swamp types. This system ranges from examples in relatively flat basins with, those with shallow organic layers over silty or sandy mineral soils and apparent seepage influence to sometimes relatively shallow, well decomposed peat. Measured pHs are typically in the 5s and 6s. It is dominated by red maple, with lesser quantities of hardwoods (black ash, yellow birch) and occasional conifers, particularly hemlock. Many of the species found in temperate peat swamps can also be found in this system, including southern and coastal species, but moderately to strongly minerotrophic conditions absent in more acidic peat swamps and indicative of this type are present (listed below). Northern conifers, shrubs, and herbs of near-boreal swamps are absent or sparse. The shrub layer is typically well developed, and the herb and bryophyte layer are well developed and diverse. *Sphagnum* mosses are usually in relatively low abundance compared to temperate peat swamp systems, but can be abundant in particularly seepy locations. These swamps support a substantial non-*Sphagnum* bryophyte layer. Strongly sloping examples on seepy silty soils often can have a great deal of *Fraxinus nigra* (black ash), *Carex lacustris* (lake sedge), or *Symplocarpus foetidus* (skunk cabbage). Shrubby openings are common in these swamps. The ***red maple – sensitive fern swamp*** community is the most common swamp type in this system. This system is often bordered by ***hemlock – cinnamon fern*** or ***red maple – red oak – cinnamon fern forests*** that are intermediate between swamp and upland forest. Examples that transition to emergent marshes may contain ***seasonally flooded red maple swamp*** and those that transition to peatlands may contain ***red maple – Sphagnum basin swamp***.

Diagnostic natural communities:

- Red maple - sensitive fern swamp (S3S4)
- Red maple - black ash - swamp saxifrage swamp (S2)
- Red maple - lake sedge swamp (S3)
- Circumneutral seepage swamp (S1)
- Highbush blueberry - winterberry shrub thicket (S4)

Peripheral or occasional natural communities:

- Hemlock - cinnamon fern forest (S4)
- Red maple - red oak - cinnamon fern forest (S3S4)
- Red maple - *Sphagnum* basin swamp (S4)
- Red maple - elm - lady fern silt forest (S1S2)
- Seasonally flooded red maple swamp (S4S5)

Associated natural community systems: In larger swamp basins this system can transition into temperate peat swamp systems. It also can transition into emergent marsh - shrub swamps.

Characteristic species:

<u>Trees and shrubs</u>

Abundant species:

Acer rubrum (red maple)

Ilex verticillata (winterberry)

Occasional to locally abundant species:

Tsuga canadensis (hemlock)

Betula alleghaniensis (yellow birch)

Vaccinium corymbosum (highbush blueberry)

Infrequent to locally abundant indicators of at least weakly minerotrophic conditions:

Fraxinus nigra (black ash)

Fraxinus americana (white ash)

Lindera benzoin (northern spicebush)

Ulmus americana (American elm)

Alnus incana ssp. *rugosa* (speckled alder),

Viburnum dentatum (northern arrowwood)

Spiraea alba (eastern meadowsweet)

Toxicodendron radicans (climbing poison ivy)

Toxicodendron vernix (poison sumac)

Sambucus canadensis (common elderberry)

Weakly minerotrophic indicators (cont.):

Lindera benzoin (northern spicebush)

Viburnum lentago (nannyberry)

Cornus sericea (red osier dogwood)

Cornus amomum (southeastern silky dogwood)

Rubus pubescens (dwarf raspberry)

<u>Herbs and bryophytes</u>

Abundant or locally abundant indicators of at least weakly minerotrophic conditions:

Onoclea sensibilis (sensitive fern)

Carex lacustris (lake sedge)

Carex stricta (tussock sedge)

Infrequent to locally abundant indicators of at least weakly minerotrophic conditions:

Impatiens capensis (spotted touch-me-not)

Caltha palustris (marsh marigold)

Viola spp. (violets)

Geum rivale (purple avens)

Symplocarpus foetidus (skunk cabbage)

Hydrocotyle americana (water pennywort)

Sphagnum squarrosum (peat moss)

Mnium spp. (mosses)

• Forest seep/seepage forest system

Landscape settings: groundwater discharge points and zones in upland forests; bases of steep slopes; slopes where slowly-pervious soil layers force groundwater to the surface

Soils: usually silty or loamy, sometimes sandy, with a shallow muck layer; poorly to very poorly drained non-riparian; moderately to strongly minerotrophic, subacid to circumneutral (mid 5s to >7); soligenous and topogenous

Spatial pattern: small patches, points, or narrow-linear zones perpendicular (e.g., slope-bases) or parallel to flow direction such as seepage runs (0.1 – 10+ acres); uniform zonation or sometimes with multiple, parallel seepage runs

Physiognomy: forest or woodland tree canopy, usually sparse to moderate shrub layer, and very dense herb and bryoid layer

Distribution: broad distribution in the state, but more common and larger examples found in northern New Hampshire

Description: This is a broadly defined, spatially small wetland system that corresponds to forest seeps; seepage runs along headwater streamlets, and to their somewhat larger counterparts of northern New Hampshire, seepage forests. These tend to be small, isolated, sloping seepage wetlands up to about 5 acres in size, with most examples being much smaller (<0.25 ac). While small, they are distinct from their surrounding upland forests. Soils are saturated to seasonally saturated, poorly to very poorly drained and have a shallow muck layer over silty or loamy (occasionally sandy) materials. pHs range from the mid 5s to over 7. They have some floristic similarities to other minerotrophic swamp systems, but they have a more limited set of vascular plants in any given example, and are more variable from one seep to another. They are well demarcated, however, by a set of seepage and other minerotrophic plants that, as a group, primarily occur in seeps. Seepage forest examples are found primarily in northern New Hampshire; examples further south tend to be small patch forest seeps. Black ash dominated swamps (black ash variant of ***northern hardwood – black ash – conifer swamp***) occur on shallow but distinctly sloping silty soils at slope-bases and around swamp margins.

Diagnostic natural communities:

- Subacid forest seep (S3S4)
- Acidic *Sphagnum* forest seep (S3S4)
- Circumneutral hardwood forest seep (S3)
- Northern hardwood seepage forest (S3)
- Northern hardwood – black ash – conifer swamp (S2)

Associated natural community systems: This system is most often embedded within upland forests, although they occasionally occur at the border of various other wetland types.

Characteristic species:

Seepage indicators:

Tiarella cordifolia (foamflower)
Carex scabrata (rough sedge)
Glyceria melicaria (northeastern manna-grass)
Circaea alpina (small enchanter's nightshade)
Aster puniceus (purple-stemmed aster)
Chrysosplenium americanum (golden saxifrage)
Platanthera dilatata (tall white bog orchid)
Galium kamtschaticum (northern wild licorice)
Geum rivale (purple avens)
Mitella diphylla (two-leaved miterwort)
Listera cordata (heart-leaved twayblade)
Listera convallarioides (lily-leaved twayblade)
Sphagnum squarrosum and other bryophytes
Cardamine pensylvanica (Pennsylvania bitter-cress)
Chelone glabra (white turtlehead)
Hydrocotyle americana (water pennywort)
Veratrum viride (false hellebore)
Carex leptalea (delicate sedge)
Carex disperma (two-seeded sedge)
Equisetum sylvaticum (wood horsetail)
Cypripedium pubescens (large yellow lady's-slipper)*
Cystopteris bulbifera (bulblet bladder fern)

This system occurs on fine mineral to organic substrates (sand, muck, or shallow muck over sand or silt) along stream drainageways or open basins (i.e., those that have an outlet). Communities are seasonally to semi-permanently flooded, with aquatic beds being permanently flooded or only intermittently exposed. Emergent marshes and aquatic bed communities found along rivers and major streams are similar to those in streamside and open-basin settings but co-occur with riverbank and river channel communities typically absent along smaller streams (see low gradient silty - sandy riverbank system).

• Emergent marsh - shrub swamp system

Landscape settings: along streams and small rivers in drainageways and in open headwater depressions

Soils: well decomposed muck and mineral soils, very poorly to poorly drained; moderately to strongly minerotrophic; pHs mostly in 5s and 6s; limnogenous

Spatial pattern: large patch (<1 - 200+ acres); extensive broad-linear shape with inlets and outlets; irregular or linear zonation (parallel to stream corridors and pond and lake margins)

Physiognomy: aquatic beds, herbaceous emergent, medium and tall shrublands and shrub thickets, forested and woodland swamp

Distribution: widespread throughout New Hampshire

Description: This system occurs on well-decomposed muck and mineral soils along small, low-gradient, seasonally flooded streams (mostly first- and second-order) and in open basins with outlet streams. Soils consist of sandy and silty mineral materials and/or well decomposed muck (often shallow organics over mineral soil). Most examples exhibit a broad flood regime gradient from permanently flooded or intermittently exposed to seasonally flooded conditions. Corresponding natural communities include ***aquatic beds***, ***shallow*** to ***deep emergent marshes***, ***peaty marshes***, ***alluvial shrub thickets***, and seasonally flooded swamps. Periodic beaver activity sets successional states back towards deeper water communities (pond, aquatic beds, or deep emergent marsh), while beaver dam abandonment and subsequent pond drainage shifts the successional track back towards shallower emergent marsh and more wooded states. Some abandoned beaver meadows consist of "peaty marshes" characterized by minerotrophic peat mosses and marsh herbs on well decomposed muck and often with standing snags indicative of raised water levels. These peaty marshes likely succeed to shrub or swamp states with continued drainage. Medium fen communities are occasionally associated with this system, particularly along sluggish drainages or in inlets away from the influence of streams. Emergent marsh and aquatic bed communities in this system also occur along lower energy sections of rivers and major streams (see also low gradient silty-sandy riverbank system), ponds, and lakes. There is considerable variation among examples of this system in terms of diversity of communities, flood regimes, and successional states present, but there is relatively little geographic variation across the state. Community composition is influenced to some extent by stream and soil characteristics (i.e., mineral vs. organic soils) and geography, although many of the natural communities in this system have wide geographic ranges. Most of the variation among examples relates to diversity of flood regime conditions and effects of beaver activity on community composition.

Diagnostic natural communities:

Emergent marshes and aquatic beds

- Tall graminoid emergent marsh (S4)
- Northern medium sedge meadow marsh (S3)
- Peaty marsh (S4)
- Short graminoid - forb emergent marsh/mud flat (S4)
- Medium-depth emergent marsh (S4)
- Deep emergent marsh - aquatic bed (S4S5)
- Cattail marsh (S4)
- Aquatic bed (S4S5)
- Herbaceous seepage marsh (S3)

Shrublands, shrub thickets, and wooded swamps

- Mixed tall graminoid - scrub-shrub marsh (S4S5)
- Highbush blueberry - winterberry shrub thicket (S4)
- Buttonbush basin swamp (S4)
- Alder alluvial shrubland (S3)
- Alder - dogwood - arrowwood alluvial thicket (S4)
- Meadowsweet alluvial thicket (S3?)
- Alluvial mixed shrub thicket (S4)
- Seasonally flooded red maple swamp (S4S5)
- Seasonally flooded boreal swamp (SU)

Associated natural community systems: Emergent marsh - shrub swamp systems are found in association with some medium level fen systems and sometimes transition to oligotrophic peat swamp or minerotrophic swamp systems.

Characteristic species:

Common shallow emergent marsh species:

Calamagrostis canadensis (bluejoint)
Carex stricta (tussock sedge)
Glyceria canadensis (rattlesnake mannagrass)
Leersia spp. (cut grasses)
Scirpus cyperinus (woolly bulrush)
Carex utriculata (bottle-shaped sedge)

Common medium-depth and deep emergent marsh species:

Pontederia cordata (pickerel weed)
Peltandra virginica (arrow arum)
Sagittaria latifolia (common arrowhead)
Sparganium americanum (lesser bur-reed)
Eleocharis palustris (marsh spike-rush)
Typha latifolia (common cattail)

Aquatic bed species:

Potamogeton spp. (pondweeds)
Brasenia schreberi (water shield)
Nuphar variegata (variegated yellow pondlily)
Nymphaea odorata (white waterlily)
Utricularia macrorhiza (common bladderwort)
Lemna minor (lesser duckweed)
Vallisneria americana (tapegrass)
Myriophyllum spp. (water milfoils)
Megalodonta beckii (water marigold)*
Persicaria hydropiperoides (mild water pepper)

Common species of shrub communities:

Ilex verticillata (winterberry)
Vaccinium corymbosum (highbush blueberry)
Alnus incana ssp. *rugosa* (speckled alder)
Viburnum nudum var. *cassinoides* (witherod)
Salix spp. (willows)
Myrica gale (sweet gale)
Spiraea alba (eastern meadowsweet)
Cephalanthus occidentalis (buttonbush)

Seepage marsh species:

Alnus incana ssp. *rugosa* (speckled alder)
Carex lacustris (lake sedge)
Impatiens capensis (spotted touch-me-not)
Onoclea sensibilis (sensitive fern)
Eupatorium maculatum (spotted Joe-pye-weed)
Symplocarpus foetidus (skunk cabbage)
Aster puniceum (purple-stemmed aster)
Toxicodendron vernix (poison sumac)
Hydrocotyle americana (water pennywort)
Carex stipata (awl sedge)
Equisetum sylvaticum (wood horsetail)
Osmunda regalis (royal fern)

SAND PLAIN POND SHORE AND BASIN MARSHES

These systems occur in sand plain settings along lake and pond shores and in closed basins with no inlets or outlets. They are distinguished from typical limnogenous wetlands (e.g., emergent marshes) by their unique geomorphic settings, floristic composition, and broadly fluctuating water levels. Vertical water fluctuations influenced by precipitation, evapotranspiration, groundwater fluctuations, and limited topographic runoff inputs dominate the hydrology in closed-basin marshes. Pond shores are also characterized by wide, seasonal water level fluctuations, but differ from basin marshes by pronounced wave action and ice scour. These systems harbor many plants restricted to or concentrated in the Atlantic coastal plain region, and contain a high proportion of the state's coastal plain flora. In more southern states, these wetlands are commonly referred to as coastal plain pond shores.

• Sandy pond shore system

Landscape settings: borders of ponds and lakes with sandy bottoms or sandy littoral zones

Soils: sand and gravel, sometimes peaty sands; poorly to very poorly drained; seasonally and semi-permanently, intermittently exposed, and permanently flooded; oligotrophic; limnogenous

Spatial pattern: extensive narrow-linear shape (2 - 50 m wide by 10 - 1000+ m in length); narrow zonation parallel to shoreline

Physiognomy: tall-medium shrub, tall herbaceous, short herbaceous, floating and submersed aquatic

Distribution: mostly east-central and southern New Hampshire, occasional further north

Description: Sandy pond shores occur primarily in central and southern New Hampshire in association with sand plain regions and occasionally along lakes in till settings where there is a local accumulation of sand along the shore. These sandy to gravelly shores and peaty sand shores are a stressful environment for plants to grow due to the infertile mineral soil, widely fluctuating water levels, and regular wave action and ice scouring. Narrow vegetation zones are strung parallel to the shoreline and relate to elevation above the lake and degree of wave and ice disturbance (ranging from shrub border to aquatic beds). While these wetlands do contain many common wetland species, a high proportion of the plants present are stress-tolerators or ruderals, and many have coastal plain affinities and are restricted to pond shores or basin marshes in New Hampshire. The primary diagnostic natural community types of this system are the ***bulblet umbrella-sedge open sandy pond shore*** and ***water lobelia aquatic sandy pond shore***. Examples with peaty sand development occur on only a few lakes (including Ossipee Lake) and are characterized by the ***twig-rush sandy pond shore*** community with a high diversity of rare coastal plain species. A few examples on Ossipee Lake have the rare ***hudsonia inland beach strand*** community, characterized by sand plain species on a dry beach ridge. Sand and gravel shores of lakes in ponds in the White Mountains and North Country have some floristic and geomorphic similarities, but lack coastal plain and southern species. Further sampling and evaluation of these examples is needed to determine if they warrant consideration as separate systems.

Diagnostic natural communities:

- Sweet gale - speckled alder shrub thicket (S3)
- Twig-rush sandy turf pond shore (S1)
- Bulblet umbrella-sedge open sandy pond shore (S2)
- Water lobelia aquatic sandy pond shore (S1S2)
- Hudsonia inland beach strand (S1)

Associated natural community systems: Sandy pond shores are always associated with ponds, lakes and adjacent, upland forest. It is sometimes associated with poor to medium level fen and emergent marsh - shrub swamp systems that typically occur behind a sandy berm or on lower-energy sections of shoreline.

Characteristic species:

Pond shore wetland communities:

Rhexia virginica (Virginia meadow beauty)
Cladium mariscoides (twig-rush)
Viola lanceolata (lance-leaved violet)
Euthamia tenuifolia (fine grass-leaved goldenrod)*
Cyperus dentatus (bulblet umbrella-sedge)
Juncus pelocarpus (mud rush)
Gratiola aurea (golden-pert)
Agalinis purpurea var. *parviflora* (small-flowered gerardia)
Eriocaulon aquaticum (pipewort)
Lobelia dortmanna (water lobelia)
Sagittaria graminea (grass-leaved arrowhead)
Sagittaria latifolia (common arrowhead)

Hudsonia inland beach strand:

Hudsonia tomentosa (hairy hudsonia)*
Hudsonia ericoides (golden-heather)*
Prunus pumila var. *cuneata* (sand cherry)
Quercus ilicifolia (scrub oak)
Pinus rigida (pitch pine)
Schizachyrium scoparium (little bluestem)
Vaccinium macrocarpon (large cranberry)

• Sand plain basin marsh system

Landscape settings: shallow depressions in outwash, ice-contact deposits and other glacio-fluvial soils; semi-perched or groundwater-connected

Soils: sand or gravelly sand with shallow muck or sandy muck surface horizons; poorly to very poorly drained; seasonally and semi-permanently flooded to intermittently exposed; oligotrophic; topogenous and groundwater influence (vertical fluctuations dominant)

Spatial pattern: small patch (<1 - 15 acres); individual basins with oval, circular and irregular shapes; occur as single basins or as clumps of separate basins in close proximity with no or only intermittent surface water connection; concentric zonation

Physiognomy: tall-medium shrub, tall herbaceous, short herbaceous, floating and submersed aquatic

Distribution: mostly east-central and southern New Hampshire, occasional further north

Description: These marshes occur in closed basins (having no inlets or outlets) in sand plain settings (outwash and other ice-contact deposits). In contrast to peatlands in closed basins, these wetlands have widely fluctuating seasonal and annual water levels, and no or relatively little organic matter accumulation in at least a portion of the basin. As with sandy pond shores, these wetlands have infertile mineral soils and support a combination of common wetland marsh plants and uncommon stress-tolerators and ruderals (including numerous coastal plain species) that are rare or infrequent in other habitats in the state. They occur primarily in central and southern New Hampshire although a few examples that lack coastal plain species can be found in the White Mountain region. Concentric vegetation zonation is typical and wave and ice action is absent. Many of the same species listed for sandy pond shore system occur in sand plain basin marshes, plus others. Examples with the ***meadow beauty sand plain marsh*** community contain numerous rare and coastal plain species that are cued into a well developed sandy drawdown zone.

Diagnostic natural communities:

- Highbush blueberry - winterberry shrub thicket (S4)
- Buttonbush basin swamp (S4)
- Meadowsweet - robust graminoid sand plain marsh (S3S4)
- Meadow beauty sand plain marsh (S1)
- Three-way sedge - manna-grass mud flat marsh (S2S3)
- Spike-rush - floating-leaved aquatic mud flat (S1)
- Sharp-flowered manna-grass shallow peat marsh (S1)
- Montane sandy basin marsh (S1)

Peripheral or occasional natural communities:

- Red maple - Sphagnum basin swamp (S4)
- Swamp white oak basin swamp (S1)
- Pitch pine - heath swamp (S1S2)

Associated natural community systems: These systems are typically set in upland forest mosaics and thus isolated from other wetlands. Occasionally they are adjacent to temperate or coastal conifer peat swamp systems with shallow organic horizons (see peripheral or occasional natural communities above).

Characteristic species:

Rhexia virginica (Virginia meadow beauty)
Cladium mariscoides (twig-rush)
Viola lanceolata (lance-leaved violet)
Euthamia tenuifolia (fine grass-leaved goldenrod)*
Cyperus dentatus (bulblet umbrella-sedge)
Juncus pelocarpus (mud rush)
Gratiola aurea (golden-pert)
Agalinis purpurea var. *parviflora* (small-flowered gerardia)
Eriocaulon aquaticum (pipewort)
Sagittaria latifolia (common arrowhead)
Eleocharis tenuis (slender spike-rush)
Panicum spretum (spurned panic-grass)
Xyris difformis (robust yellow-eyed grass)

Riparian and Tidal (Estuarine) systems, clockwise from top left:

1. ***Red maple floodplain forest*** community, with arching musclewood stems, within a temperate minor river floodplain system. Soucook River, Loudon. Photo DDS.
2. ***Silver maple – false nettle – sensitive fern floodplain forest*** community within a major river silver maple floodplain forest system. Technical Institute, Concord. Photo Doug Bechtel.
3. Moderate-gradient sandy – cobbly riverbank system showing a rapid community sequence from a ***twisted sedge low riverbank*** to ***blue-joint – goldenrod – virgin's bower riverbank/floodplain*** to ***alder alluvial shrubland*** to ***balsam fir floodplain/silt plain.*** Indian Stream, Pittsburg. Photo DDS.
4. Salt marsh system with ***brackish marsh*** (foreground), ***high salt marsh*** (middle) and ***low salt marsh*** (background) and cattle egrets. Sandy Point, Stratham. Photo BDK.
5. ***Dwarf cherry river channel*** community w/in moderate gradient sandy-cobbly riverbank system. Livermore Falls, Holderness. Photo DDS.

RIPARIAN (NON-TIDAL)

The following systems correspond to riparian zones at the terrestrial – aquatic interface: some of the constituent communities are jurisdictional wetlands and some are not, but all are dramatically influenced by periodic river flooding. They occur primarily along third and higher order streams and rivers and include stream and river floodplains, river channels, and river banks).

These riparian systems on mineral soils are broken into two broad groups: 1) river channels and riverbank systems that occur below the bankful stage of a river (the river level at which the river spills onto its floodplain); and 2) floodplains, which are flooded by the river when the river spills over its banks. Bankful stage on rivers worldwide occurs on average on a 2-3 year return interval. Alluvial shrub thickets on smaller rivers and large streams can occur on annually flooded floodplains that occur elevationally below a higher floodplain forest (when present) or upland forest.

RIVER CHANNELS AND RIVERBANKS

River channels are areas between riverbanks. Riverbanks are the elevated ground bordering and containing a river. Low riverbanks are immediately adjacent to river channels and are typically inundated for substantial portions of the year. Substrates are variable in these settings with composition dependent on the slope gradient of the river and position relative to the main channel. High-energy environments are indicated by sand, gravel, cobble, boulder, or bedrock substrate where fast currents scour and transport finer particles downstream. These settings tend to have a sparse or low percent cover of plants. Low to moderate-energy environments are indicated by sand or silt substrate and may range from sparse to moderate plant cover.

Although energy level is an important variable that affects community composition within river systems, river gradient appears to be a more stable predictor of the overall community assemblage than energy per se; energy level varies with gradient, elevation, and river stage (high or low, rising or falling), whereas river gradient better represents the long term average condition. High gradient rivers often transport fine sediments at high or low stage, whereas low gradient rivers may only transport fine sediments at a particular stage level. The following three river channel/riverbank systems occur largely in moderate- to high-energy environments along rivers and large streams in the state. Most occur on mineral or rock substrate with relatively little organic matter accumulation. Lower gradient rivers can also have emergent marshes on muck substrate, aquatic beds, and other communities associated with lower energy settings.

• Low-gradient silty-sandy riverbank system

Landscape settings: river channels and riverbanks (below the bankful flood-stage level) along low gradient sections of rivers and large streams (with or without well developed adjacent floodplain)

Soils: primarily alluvial sands, loams, and silt loams; moderately minerotrophic

Spatial pattern: extensive narrow-linear patches (several meters wide and miles long); linear zones parallel to river or patchy zonation corresponding to intermittent bar deposits

Physiognomy: tall shrub, medium-height shrub, herbaceous emergent, sparsely vegetated, aquatic

Distribution: broadly distributed throughout the state

Description: This system corresponds to sandy or silty river channels and riverbanks along low gradient, low to moderate energy, meandering sections of large streams and minor rivers. Sandy or silty channel bars are occasional, but gravel and cobble bars are relatively rare or absent in this depositional environment. Aquatic bed and emergent marsh communities are common, whereas these are typically absent or not well developed in higher energy settings of moderate- and high-gradient sections of river. These communities are typically indicated by a higher density of vegetation and emergent marsh forbs, including species absent from high-energy environments. Typically, this system has a high diversity of species.

Shrubbier portions of this system are characterized by alder, dogwoods, and Viburnums, and sometimes a diverse assemblage of other shrubs. Adjacent floodplains typically have red or silver maple floodplain forest communities, but examples of this system may lack well-developed wooded floodplain forests. Instead they may have extensive alluvial alder floodplains along large streams that are flooded at least annually, or they may transition rapidly to upland.

Diagnostic natural communities:

<u>River channels and low riverbanks</u>

- Cobble - sand river channel (S3S4)
- Herbaceous sandy river channel (S4)
- Twisted sedge low riverbank (S3S4)

<u>Riverbanks</u>

- Herbaceous riverbank/floodplain (S2S4)
- Blue-joint - goldenrod - virgin's bower riverbank/floodplain (S3S4)
- Alder alluvial shrubland (S3)
- Alder - dogwood - arrowwood alluvial thicket (S4)
- Meadowsweet alluvial thicket (S3?)

<u>Emergent marshes and aquatic beds</u>

- Short graminoid - forb emergent marsh/mud flat (S4)
- Medium-depth emergent marsh (S4)

- Cattail marsh (S4)
- Deep emergent marsh - aquatic bed (S4S5)
- Aquatic bed (S4S5)

Associated natural community systems: This system is most often associated with temperate minor river and major river silver maple floodplain systems, and rarely montane/near boreal floodplains that occur on large streams.

Characteristic species:

Herbaceous river channel and riverbank communities:

Poa spp. (blue-grasses)
Agrostis spp. (bent grasses)
Calamagrostis canadensis (blue-joint)
Panicum spp. (panic grasses)
Carex torta (twisted sedge)
Apocynum sibiricum (prairie dogbane)
Aster spp. (asters)
Solidago spp. (goldenrods)
Polygonum spp. (smartweeds)
Eupatorium spp. (Joe-pye-weeds)
Hieracium spp. (hawkweeds)
Equisetum arvense (field horsetail)
Glyceria and *Puccinellia* spp. (manna-grasses)
Leersia spp. (cut-grasses)
Juncus spp. (rushes)
Eleocharis spp. (spike-rushes)
Carex lupulina (hop sedge)
Carex crinita (drooping sedge)
Scirpus torreyi (Torrey's threesquare)
Scirpus smithii (Smith's bulrush)
Scirpus cyperinus (woolly bulrush)

Herbaceous species (cont.):
Bulbostylis capillaris (hair sedge)
Cicuta spp. (water-hemlocks)
Sium suave (water parsnip)
Impatiens capensis (spotted touch-me-not)
Thelypteris palustris (marsh fern)
Onoclea sensibilis (sensitive fern)
Osmunda cinnamomea (cinnamon fern)
Triadenum virginicum (marsh St. John's-wort)
Bidens spp. (sticktights)
Lycopus uniflorus (common water horehound)
Iris versicolor (northern blue flag)
Lysimachia terrestris (swamp candles)

Shrub and vines of riverbank and river channel communities:

Alnus incana ssp. *rugosa* (speckled alder)
Alnus serrulata (smooth alder)
Cornus spp. (dogwoods)
Viburnum spp. (viburnums)
Clematis virginiana (virgin's bower)
Spiraea alba (eastern meadowsweet)

• Moderate-gradient sandy-cobbly riverbank system

Landscape settings: river channels and riverbanks (below the bankful transition to floodplain) along moderate-gradient sections of rivers and large streams

Soils: primarily alluvial sand, gravel, and cobble; oligotrophic to moderately minerotrophic

Spatial pattern: large patch, extensive narrow-linear (typically 5+ m wide and up to miles long); linear zones parallel to riverbanks or patchy zonation corresponding to intermittent bar deposits

Physiognomy: sparse woodland, tall shrub, medium-height shrub, herbaceous, sparsely vegetated, aquatic

Distribution: broadly distributed throughout the state

Description: This system is associated with moderate gradient, moderate to high-energy sections of major and minor rivers with frequent sand, gravel, and cobble bar deposits and coarse-textured riverbanks. Ice and flood scour are important annual disturbances, producing sparse to moderate cover of herbs and shrubs on coarse substrates. Thus the natural communities in this system on average are sparsely vegetated. Rapids or riffle sections are common among the depositional bars. Floodplain forests (primarily silver maple, sugar maple, and balsam fir types) are often adjacent to this riverbank system. This system lacks extensive deposits of boulders and rock that are characteristic of high-gradient rocky riverbanks. It has a higher abundance of coarse deposits (gravel to cobble) compared to low-gradient silty-sandy riverbanks. This system includes extensive alder thickets on large northern streams or small rivers that are flooded at least annually but lack floodplain forests.

This system lacks well-developed emergent marsh vegetation found in low-gradient riverbank systems.

Diagnostic natural communities:

<u>River channels and low riverbanks</u>

- Hudsonia - silverling river channel (S1)
- Dwarf cherry river channel (S2)
- Boulder - cobble river channel (S3)
- Cobble - sand river channel (S3S4)
- Herbaceous sandy river channel (S4)
- Willow low riverbank (S3)
- Twisted sedge low riverbank (S3S4)
- Herbaceous low riverbank (S3S4)

<u>Medium to high riverbanks and open floodplains</u>

- Herbaceous riverbank/floodplain (S2S4)
- Herbaceous/wooded riverbank/floodplain (S4)
- Blue-joint - goldenrod - virgin's bower riverbank/floodplain (S3S4)
- Riverbank/floodplain fern glade (SU)
- Alder alluvial shrubland (S3)

- Alluvial mixed shrub thicket (S4)
- Acidic riverbank outcrop (S3)
- Circumneutral riverbank outcrop (S1)
- Acidic riverside seep (S1)
- Calcareous riverside seep (S1)

Associated natural community systems: This system is associated with all three floodplain systems or may occur without a well-developed forested floodplain along upper reaches of large mountain streams with annually flooded shrub floodplains. Montane/near-boreal floodplain systems are almost always associated with this riverbank system (but not vice-versa).

Characteristic species:

Species diagnostic of this system (generally not found on low-gradient silty-sandy riverbanks):

Prunus pumila var. *susquehanae* (dwarf cherry)
Prunus pumila var. *depressa* (dwarf cherry)
Schizachyrium scoparium (little bluestem)
Andropogon gerardii (big bluestem)
Vaccinium cespitosum (dwarf bilberry)
Calamagrostis pickeringii (Pickering's reed bent-grass)
Solidago randii (Rand's goldenrod)
Hudsonia tomentosa (hairy hudsonia)
Paronychia argyrocoma var. *albimontana* (silverling)

• High-gradient rocky riverbank system

Landscape settings: river channels and riverbanks along high-gradient sections of rivers and large streams; below the bankful flood-stage of river marked by transition to floodplain (when floodplain is present)

Soils: primarily bedrock, boulders, stones, and some cobble with interstitial sand and gravel; oligotrophic to moderately minerotrophic

Spatial pattern: large patch, extensive narrow-linear (typically 5+ m wide and up to miles long); linear zones parallel to riverbanks or patchy zonation corresponding to intermittent cobble bar deposits

Physiognomy: sparse woodland, tall to medium-height shrub, herbaceous, sparsely vegetated

Distribution: most common in the White Mountains and north, and scattered along upper reaches and intermittent steep-gradient sections of minor and major rivers throughout much of the state

Description: River channels and banks in steep gradients are degradational environments in which fine sediments are transported downstream at high or low river stages, leaving boulders and bedrock as the dominant channel substrate. Ice and flood scour are pronounced. Meanders and bars comprised of finer sediments are sparse. High-gradient rocky riverbanks are extensive along the upper reaches of rivers leading out of the mountains, and scattered on high-gradient sections of other rivers elsewhere in the state. Sparsely vegetated boulders and some cobble are characteristic channel and riverbank material, often with sand in the interstices. Exposures of sediments finer than cobble are intermittent or rare. Riverbank fern glades, alder alluvial thickets, or other herbaceous to wooded vegetation occurs on slightly higher riverbanks. Outcrops are present in some examples; riverside seeps are rare. Rare or uncommon northern and subalpine plants are found in this system along northern rivers (not found in low energy settings or southern New Hampshire).

Diagnostic natural communities:

River channels

- Boulder - cobble river channel (S3)
- Cobble - sand river channel (S3S4)

Riverbanks

- Alder alluvial shrubland (S3)
- Herbaceous/wooded riverbank/floodplain (S4)
- Riverbank/floodplain fern glade (SU)
- Acidic riverbank outcrop (S3)
- Circumneutral riverbank outcrop (S1)
- Acidic riverside seep (S1)
- Calcareous riverside seep (S1)

Associated natural community systems: This system typically borders upland forests on till or high river terraces and does not occur along river sections with well-developed floodplains. Occasionally it is adjacent to the upper reaches of montane/near-boreal floodplain systems.

Characteristic species:

Trees and shrubs

Alnus incana ssp. *rugosa* (speckled alder)

Salix spp. (willows)

Seedlings and saplings of tree species

Herbs

Osmunda claytoniana (interrupted fern)

Deschampsia caespitosa (blue-green hair-grass)

Deschampsia flexuosa (common hair-grass)

Calamagrostis canadensis (blue-joint)

Danthonia spicata (poverty oat-grass)

Panicum spp. (panic grasses)

Aster umbellatus (tall flat-topped white aster)

Solidago bicolor (silverrod)

Other composites

Eupatorium maculatum (spotted Joe-pye-weed)

Houstonia caerulea (bluets)

Carex torta (twisted sedge)

Fragaria virginiana (wild strawberry)

Rare or uncommon northern and subalpine plants:

Vaccinium cespitosum (dwarf bilberry)*

Calamagrostis pickeringii (Pickering's reed bent-grass)*

Calamagrostis stricta ssp. inexpansa (pond reed bent-grass)

Hieracium robinsonii (Robinson's hawkweed)*

Agrostis mertensii (boreal bent-grass)

Riverside seeps:

Tofieldia glutinosa (sticky false asphodel)*

Drosera rotundifolia (round-leaved sundew)

Carex garberi var. *bifaria* (Garber's sedge)*

FLOODPLAINS

River floodplains are diverse ecosystems that occur at the interface between the aquatic and terrestrial environments in river valley bottomlands adjacent to river channels. They are dynamic environments affected by periodic, temporary flooding. As water levels rise over riverbanks, sediment transported from upstream is deposited where water slows and spreads out across the floodplain terraces (Wistendahl 1958; Jorgenson 1978). Coarse sediments fall out along edges of main channels forming natural sandy levees, while finer, silty sediments settle on flat, higher terraces behind the levees. Mixing and churning flood waters can create a mosaic of different soil conditions and microtopographic variability within the floodplain (Bornette and Amoros 1996; Hupp 1986; Hupp and Osterkamp 1985; Barnes 1978). Soil drainage ranges from well drained coarse sands on levees, to poorly drained silts and mucks in floodplain sloughs and oxbows, vernal pools, and microtopographic depressions.

The combination of floodplain forest and open floodplain communities (e.g., oxbows, meadows, and thickets) largely depends on river watershed size, gradient, and channel morphometry, which in turn affect the timing, frequency, intensity, and duration of flooding. By definition, river floodplains occur above bankful stage. Return intervals for low floodplains in New Hampshire are approximately every one to three years. Medium and high floodplains have longer return intervals. Most non- or only partially-wooded floodplain communities occur on low floodplains. Depressional sloughs, oxbows, vernal pools, and other micro-topographic depressions within the floodplain tend to pond flood waters and are inundated for longer periods than low floodplains. High terraces are inactive floodplains that are essentially isolated from flood dynamics, with flood intervals that exceed 100 years, and are not considered part of floodplain systems described here. The lack of periodic flooding allows for soils to develop to a greater extent (soil horizon development) and vegetation generally consists of upland species not restricted to floodplains.

• Montane/near-boreal floodplain system

Landscape settings: floodplains (above bankful) along moderate-gradient sections of rivers and large streams

Soils: sandy alluvium (loamy sand, sandy loam, silt loams, and occasionally sand over gravel or cobble); moderately minerotrophic

Spatial pattern: large patch, extensive broad-linear (<1 - 50+ acres); meandering linear and semi-circular zones parallel to riverbanks or corresponding to floodplain terracing and oxbow, slough, or over-flow channel formations

Physiognomy: forest, woodland, sparse woodland, tall to medium-height shrub, herbaceous, and aquatic

Distribution: primarily found on flashy northern rivers in the White Mountains or north country, and occasional in north-central New Hampshire

Description: This floodplain system is associated with montane and northern rivers in New Hampshire that often have flashy flood regimes and relatively high-gradients compared to other river systems. Flashy flood regimes are those affected by high intensity, short-duration floods from mountain runoff events. The most diagnostic natural communities are sugar maple and balsam fir floodplain forests, and occasionally red maple floodplain forest. When silver maple floodplain forests are present they typically form a narrow border and are not the dominant forest type. Moderate gradient sandy-cobbly riverbanks are typically adjacent to these floodplains, although some examples occur on higher- or lower-gradient sections of river. Some smaller, northern river floodplains contain balsam fir floodplain/silt plains and alder thickets that lack sugar maple floodplain forest communities.

Examples along larger rivers with ***sugar maple – ironwood – short husk floodplain forest*** contain mixes of sugar maple, ironwood, and other common upland trees. Shrubs are generally not dominant, except at forest edges. Compared to average northern hardwood forests, the herb layer is often more lush – commonly with a high total coverage, and a species composition indicative of semi-rich conditions. ***Sugar maple – silver maple – white ash floodplain forest*** can occur on lower adjacent floodplains, marked by the appearance of silver maple and more mesic site plants. ***Balsam fir floodplain/silt plain*** have a somewhat less floristically rich flora that lacks ironwood and contains more softwoods, and common wet-site herbs of northern NH.

Diagnostic natural communities:

<u>Floodplain forests</u>

- Sugar maple - ironwood - short husk floodplain forest (S1)
- Sugar maple - silver maple - white ash floodplain forest (S1S2)
- Balsam fir floodplain/silt plain (S2)

<u>Herbaceous and shrubby floodplains</u>

- Herbaceous riverbank/floodplain (S2S4)
- Herbaceous/wooded riverbank/floodplain (S4)
- Blue-joint - goldenrod - virgin's bower riverbank/floodplain (S3S4)

- Riverbank/floodplain fern glade (SU)
- Alder alluvial shrubland (S3)
- Alluvial mixed shrub thicket (S4)
- Oxbow marsh (S3)

Peripheral or occasional natural communities:

- Silver maple – false nettle – sensitive fern floodplain forest (S2)

Associated natural community systems: Moderate gradient sandy-cobbly riverbanks are typically adjacent to these floodplains, although some examples occur on higher- or lower-gradient sections of river.

Characteristic species:

Sugar maple - ironwood - short husk floodplain forest:

Trees

Acer saccharum (sugar maple)
Ostrya virginiana (ironwood)
Quercus rubra (red oak)
Fraxinus americana (white ash)
Prunus serotina (black cherry)
Pinus strobus (white pine)

Herbs

Solidago caesia (blue-stemmed goldenrod)
Uvularia sessilifolia (sessile-leaved bellwort)
Toxicodendron radicans (climbing poison ivy)
Aralia nudicaulis (wild sarsaparilla)
Carex pedunculata (long-stalked sedge)
Brachyelytrum erectum (northern short husk grass)

Balsam fir floodplain/silt plain:

Trees and shrubs

Abies balsamea (balsam fir)
Acer rubrum (red maple)
Pinus strobus (white pine)
Alnus incana ssp. *rugosa* (speckled alder)

Herbs

Calamagrostis canadensis (blue-joint)
Carex stricta var. *strictior* (small-tussock sedge; non-tussock forming)
Spiraea alba (eastern meadowsweet)
Coptis trifolia (goldthread)
Cornus canadensis (bunchberry)
Aster acuminatus (whorled aster)

• Major river silver maple floodplain system

Landscape settings: floodplains (above bankful) along moderate-gradient and low-gradient sections of major rivers

Soils: sandy to silty alluvium (loamy sand, sandy loam, silt loams); moderately to strongly minerotrophic

Spatial pattern: large patch, extensive broad-linear (< 1 - 50+ acres); meandering linear and semi-circular zones parallel to riverbanks or corresponding to floodplain terracing and oxbow, slough, or over-flow channel formations

Physiognomy: forest, woodland, sparse woodland, tall to medium-height shrub, herbaceous, and aquatic

Distribution: found primarily along the main-stems of the Connecticut and Merrimack Rivers, and occasionally on lower reaches of major tributaries

Description: Floodplains corresponding to this system occur along major rivers in New Hampshire (e.g., the Connecticut and Merrimack) and are indicated by the dominance of one or both types of silver maple floodplain forest, and sometimes oxbow marshes and various meadow and thicket communities. Flooding on these rivers is affected by snowmelt from the White Mountains that peaks a bit later in the spring than melting snowpacks along more minor tributaries, and by the much larger water volume found on these main-stem rivers. Forest canopies are dominated by mature *Acer saccharinum* (silver maple), which forms a tall, arching, cathedral-like ceiling above the level floodplain adjacent to the river channel. Whereas shrubs are poorly represented, vines (including grapes) tend to be abundant, especially in canopy gaps and along forest edge transitions to other communities. The ***silver maple – wood nettle – ostrich fern floodplain forest*** type is most common along the Connecticut River, while the ***silver maple – false nettle – sensitive fern*** type is most common on the Merrimack and its larger tributaries (e.g., Ashuelot, Contoocook, Suncook). This type exhibits different dominant herbs and generally more grasses and sedges. On more minor rivers silver maple floodplain forest communities are reduced to a narrow band or relatively small portion of the floodplain system compared to other forest types or disappear altogether. Red maple and other floodplain forest types predominate when silver maple disappears.

Floodplain forests of this system often form a mosaic with more open floodplain communities. Shrub thickets and herbaceous meadows may occur on low floodplains and adjacent riverbanks. Aquatic beds, emergent marshes and shrub thickets in oxbows may also occur and are typically flooded annually. ***Riverwash sand dunes*** occur on a few sandy pointbar floodplains of the Merrimack River and are kept open by some combination of infrequent scouring by major floods and subsequent shifting windblown sands. Flood regimes have been altered considerably by dam control of major flood events, lengthening the return interval of medium and high floodplains along some sections of river. Invasive plants are problematic in many examples of this system, particularly *Celastrus orbiculatus* (Asian bittersweet) and *Berberis thunbergii* (Japanese barberry).

Diagnostic natural communities:

- Silver maple - wood nettle - ostrich fern floodplain forest (S2)
- Silver maple - false nettle - sensitive fern floodplain forest (S2)

- Herbaceous riverbank/floodplain (S2S4)
- Blue-joint - goldenrod - virgin's bower riverbank/floodplain (S3S4)

Diagnostic natural communities (continued):

- Alder alluvial shrubland (S3)
- Alder - dogwood - arrowwood alluvial thicket (S4)
- Oxbow marsh (S3)
- Oxbow buttonbush swamp (S3)
- Aquatic bed (S4S5)

Peripheral or occasional natural communities:

- Sugar maple - silver maple - white ash floodplain forest (S1S2)
- Red maple floodplain forest (S3)
- Riverwash sand dune (S1 – newly described)

Associated natural community systems: Most often this system is adjacent to the low-gradient silty-sandy riverbank system and sometimes the moderate-gradient sandy-cobbly riverbank. It often transitions to river terraces dominated by upland forest types, and in some locales to rich sugar maple - oak - hickory terrace forest.

Characteristic species:

Silver maple - wood nettle - ostrich fern floodplain forest:

Trees

Abundant species:
Acer saccharinum (silver maple)
Occasional to locally abundant:
Fraxinus americana (white ash)
Ulmus americana (American elm)
Populus deltoides (eastern cottonwood)
Celtis occidentalis (hackberry)
Juglans cinerea (butternut)

Herbs and vines

Dominant to abundant species:
Matteuccia struthiopteris (ostrich fern)
Laportea canadensis (wood nettle)
Occasional, never dominant:
Onoclea sensibilis (sensitive fern)
Athyrium filix-femina (northern lady fern)
Cinna arundinacea (common woodreed)
Boehmeria cylindrica (false nettle)

Occasional species (cont.):
Impatiens capensis (spotted touch-me-not)
Thalictrum pubescens (tall meadow-rue)
Arisaema triphyllum (Jack-in-the-pulpit)
Vitis riparia (river grape)
Rare species:
Arisaema dracontium (green dragon)*

Silver maple - false nettle - sensitive fern floodplain forest:

Trees

Abundant species:

Acer saccharinum (silver maple)

Occasional to locally abundant:

Ulmus americana (American elm)

Herbs and vines

Dominant species:

Onoclea sensibilis (sensitive fern)

Boehmeria cylindrica (false nettle)

Silver maple - false nettle - sensitive fern floodplain forest (cont.):

Occasional to locally abundant species:

Toxicodendron radicans (climbing poison ivy)

Cinna latifolia (drooping woodreed)

Cinna arundinacea (common woodreed)

Carex crinita (drooping sedge)

Carex intumescens (inflated sedge)

Athyrium filix-femina (northern lady fern)

Impatiens capensis (spotted touch-me-not)

Thalictrum pubescens (tall meadow-rue)

Arisaema triphyllum (Jack-in-the-pulpit)

Matteuccia struthiopteris (ostrich fern)

• Temperate minor river floodplain system

Landscape settings: floodplains (above bankful) along moderate-gradient and low-gradient sections of minor rivers and large streams

Soils: sandy to silty alluvium (loamy sand, sandy loam, silt loams); moderately to strongly minerotrophic

Spatial pattern: large patch, extensive broad-linear (< 1 - 50+ acres); meandering linear and semi-circular zones parallel to riverbanks or corresponding to floodplain terracing and oxbow, slough, or over-flow channel formations

Physiognomy: forest, woodland, sparse woodland, tall to medium-height shrub, herbaceous, and aquatic

Distribution: found along major streams and minor rivers throughout central and southern NH

Description: This system corresponds to hardwood-dominated floodplains in central and southern New Hampshire along large streams and minor rivers, including the tributaries of the Merrimack and Connecticut Rivers and rivers in the Piscataqua and Ossipee River watersheds. It is indicated by the dominance of ***red maple floodplain forests*** and occasionally other types (e.g. sycamore, swamp white oak, and balsam fir), often in a mosaic with oxbow marshes, vernal pools, and floodplain meadows and thickets. Silver maple floodplain forests may form a narrow border or small patches but do not dominate extensive areas as they do along the main-stems of major rivers. Canopies of these forests are strongly dominated by *Acer rubrum* (red maple), and the understory ranges from open to viny and somewhat shrubbier than silver maple floodplains, with an abundance of ferns. Compared to their major river counterparts, minor river floodplains appear to have reduced flood intensity, duration, and earlier peak floods due to absence or reduced importance of mountain snow-pack meltwater. This system includes ***swamp white oak*** and ***basswood – white ash – black maple floodplain forests*** restricted to silty alluvial and marine sediments in the coastal region. Low, medium, and high floodplain variants are distinguishable in many occurrences, which correspond to slightly different elevations and thus flood return intervals. These are marked by corresponding shifts in abundance of species preferential to wetter or drier conditions. Invasive plants are problematic in many examples of this system, particularly *Celastrus orbiculatus* (Asian bittersweet) and *Berberis thunbergii* (Japanese barberry).

Diagnostic natural communities:

<u>Floodplain forests</u>

- Red maple floodplain forest (S2S3)
- Silver maple - false nettle - sensitive fern floodplain forest (S2)
- Balsam fir floodplain/silt plain (S2)
- Sycamore floodplain forest (S1)
- Swamp white oak floodplain forest (S1)
- Basswood - white ash - black maple floodplain forest (S1)

<u>Herbaceous and shrub floodplain communities</u>

- Herbaceous riverbank/floodplain (S2S4)

- Blue-joint - goldenrod - virgin's bower riverbank/floodplain (S3S4)
- Alder alluvial shrubland (S3)
- Alder - dogwood - arrowwood alluvial thicket (S4)
- Meadowsweet alluvial thicket (S3?)
- Oxbow marsh (S3)
- Oxbow buttonbush swamp (S3)

Associated natural community systems: This system frequently occurs in association with low-gradient silty-sandy riverbank systems and less commonly with moderate-gradient sandy-cobbly riverbanks.

Characteristic species:

Floodplain forest communities:

Trees

Abundant:

Acer rubrum (red maple)

Occasional to locally abundant:

Prunus serotina (black cherry)
Carya ovata (shagbark hickory)
Quercus rubra (red oak)
Quercus bicolor (swamp white oak)
Fraxinus americana (white ash)
Tilia americana (basswood)

Shrubs

Carpinus caroliniana (musclewood)
Ilex verticillata (winterberry)
Viburnum spp. (viburnums)
Vaccinium corymbosum (highbush blueberry)
Cornus amomum (southeastern silky dogwood)
Toxicodendron radicans (climbing poison ivy)

Herbs

Onoclea sensibilis (sensitive fern)
Osmunda regalis (royal fern)

Floodplain forest herbs (cont.):

Athyrium filix-femina (northern lady fern)
Boehmeria cylindrica (false nettle)
Impatiens capensis (spotted touch-me-not)

Common species of shrub and herbaceous floodplain communities:

Shrubs

Alnus incana ssp. *rugosa* (speckled alder)
Cornus sericea (red osier dogwood)
Salix sericea (silky willow)
Clematis virginiana (virgin's bower)
Spiraea alba (eastern meadowsweet)
Cephalanthus occidentalis (buttonbush)

Herbs

Calamagrostis canadensis (bluejoint)
Solidago rugosa (rough goldenrod)
Solidago gigantea (giant goldenrod)
Onoclea sensibilis (sensitive fern)
Euthamia graminifolia (flat-topped goldenrod)
Aster umbellatus (flat-topped white aster)
Carex vesicaria (inflated sedge)
Carex stricta (tussock sedge)
Carex crinita (drooping sedge)
Carex lupulina (hop sedge)

TIDAL (ESTUARINE)

Estuarine systems in New Hampshire occur in subtidal and intertidal areas connected to the ocean but semi-enclosed by land and protected from high-energy wave action. Subtidal habitats are influenced by tides but are continuously submerged. Intertidal habitats are periodically exposed and flooded by tides (including spring tide and splash zone areas). Water within the estuarine system is at least occasionally diluted by freshwater runoff, and is distinguished from freshwater by salinity levels of >0.5 parts per thousand (ppt). The estuarine system extends seaward to an imaginary line drawn across the mouth of a bay or river or to the seaward limit of wetland vascular plants when they are not included within the imaginary line. Upstream and landward the system extends to where ocean-derived salts are less than or equal to 0.5 ppt during the period of average annual low freshwater flow (Cowardin et al. 1979).

Surface water salinity fluctuates widely according to seasonal variation in freshwater discharge. Salt marsh soil water salinity roughly corresponds to polyhaline levels (18–30 ppt). In certain areas, evaporation may increase salinity above polyhaline levels. Salinity levels less than 18 ppt but greater than 0.5 ppt (meso- and oligohaline levels) typically support brackish marsh communities. Freshwater emergent marshes occur where salinity levels are 0.5 ppt or less during the period of annual low freshwater flow.

INTERTIDAL

Intertidal systems are intermittently flooded and exposed by tidal fluctuation. They can be broken into three broad groups according to flooding frequency: upper, middle, and lower intertidal. These flood regimes have an important influence in structuring vegetation within each system described below. The *upper intertidal* is the irregularly flooded zone (substrate flooded less than daily) occurring between the upper reaches of the spring tide/splash zone and mean high tide. It includes high salt marsh, brackish marsh, high marsh pannes and pools, high brackish tidal riverbank marsh, and coastal shoreline strand/swale communities. The upper intertidal zone also supports coastal salt pond marshes, which are wetlands lying beyond the upper reach of spring tides but periodically infused with salt water during storm events. *Middle intertidal* refers to the regularly flooded zone (substrate flooded at least once daily) occurring between the mean high tide and mean low tide, which supports low salt marsh, low marsh pannes and pools, low brackish tidal riverbank marsh, saline/brackish intertidal flat, and intertidal rocky shore natural communities. The *lower intertidal* is the irregularly exposed zone (substrate exposed less than daily) occurring between the mean low tide and very low spring tide, which supports the lower reaches of the saline/brackish intertidal flat and intertidal rocky shore natural communities.

• Salt marsh system

Landscape settings: intertidal coastal embayments

Soils: marine peat; organic materials 16 to 50" thick overlying sandy materials (low marsh); organic materials >50" over sand, silt, or bedrock (high marsh); shallow peats (<16") are occasional in areas towards outer limits of salt marsh (seaward and inland); poly-haline (18 - 30 ppt), strongly minerotrophic

Spatial pattern: large patch, narrow-linear to irregularly linear (<1 - 100+ acres); narrow to broad linear bands fringing coastal shorelines, with scattered orbicular patches: linear bands of low salt marsh; broad-linear patches of high salt marsh; intermittent strands of brackish marsh along upland border; small orbicular patches of pannes and pools

Physiognomy: primarily herbaceous

Distribution: occurs at Great Bay, in the Blackwater River estuary, and in other coastal embayments

Description: Salt marsh systems include upper and middle intertidal areas corresponding to high and low salt marsh, respectively, with an intermittent brackish marsh border along upland edge. Small salt pools and pannes are common, particularly in the high marsh. Salt marsh soil water salinity roughly corresponds to polyhaline levels (18–30 ppt). In pannes and pools, evaporation may increase salinity above polyhaline levels. Salt marshes grow atop fibrous marine peat. The transition between high and low salt marsh occurs approximately at the mean high water mark; from here high salt marsh stretches landward to the upper reaches of spring tides. Brackish marshes occur where freshwater runoff along the upland border reduces salt concentrations to meso-haline levels.

Low salt marshes are dominated by *Spartina alterniflora* (smooth cord-grass) and occur between mean sea level and mean high tide in areas protected from high-energy wave action. Other vascular halophytes occur in low abundance. Macroalgae (seaweed) may also be present. ***High salt marshes*** are strongly dominated by *Spartina patens* (salt-meadow cord-grass), with lesser amounts of other graminoids. ***Brackish marshes*** are often indicated by *Scirpus robustus* (stout bulrush), *Carex paleacea* (chaffy salt sedge), and *Typha angustifolia* (narrow-leaved cattail), among other species. ***Salt pannes and pools*** (pools are deeper) are low wet areas isolated from tidal creeks that occur in both saline and brackish marshes where they form fine-scale natural communities (less than $1m^2$ to over 100 m^2). Salinity levels in pannes found in the high salt marsh are typically in the range of 40–50(-60) ppt. Species composition varies with salinity, hardness of substrate, elevation, soil oxygen, hydroperiod, and other factors.

The ability of individual plant species to tolerate the unique combination of stresses in salt marshes dictate which plant species grow where. There are numerous factors that affect plant distribution: hydroperiod (duration and frequency of tidal flooding), soil salinity, soil oxygen, nutrient availability, elevation of substrate, concentration of growth inhibitors, storms, ice-scouring, land use history, and competitive interactions and biological facilitation between and among species. Many of these factors and processes are interrelated, but vary along gradients at different rates or in different quantities.

Between the time of European settlement until recently, salt marshes were routinely drained by farmers to increase the productivity of salt-meadow cord-grass and spike-grass for hay, pasture, mulch, and in an effort to reduce salt marsh mosquito (*Aedes sollicitans*) populations. The ecological impacts of ditching

include reduced flood duration and lowered water table and changes in species composition across many groups of species in the marsh (insects, mollusks, crustaceans, shorebirds, waterfowl, and plants).

Diagnostic natural communities:

- Low salt marsh (S3)
- High salt marsh (S3)
- Salt pannes and pools (S3)

Peripheral or occasional natural communities:

- Brackish marsh (S2S3)
- Coastal salt pond marsh (S1)

Associated natural community systems: Salt marsh systems transition to brackish tidal riverbank marsh upstream and sparsely vegetated intertidal towards the subtidal zone.

Characteristic species:

Low salt marsh:

Abundant species:
Spartina alterniflora (smooth cordgrass)
Occasional to locally abundant:
Salicornia europaea (common glasswort)
Atriplex spp. (orachs)
Eleocharis parvula (small spike-rush)
Suaeda spp. (sea blites)
Spergularia marina (seabeach sand-spurrey)
Ascophyllum nodosum (a seaweed)
Fucus spp. (rockweeds)

High salt marsh:

Dominant:
Spartina patens (salt-meadow cord-grass)
Occasional species
Spartina alterniflora (smooth cord-grass; short form)
Distichlis spicata (spike-grass)
Juncus gerardii (salt marsh rush)

Brackish marsh:

Scirpus robustus (stout bulrush)
Carex paleacea (chaffy salt sedge)
Typha angustifolia (narrow-leaved cattail)

Salt pannes and pools:

Triglochin maritimum (arrow-grass)
Spartina alterniflora (smooth cord-grass; short form)
Ruppia maritima (widgeon-grass)
Scirpus maritimus (saltmarsh bulrush)
Potamogeton pectinatus (sago pondweed)
Zannichellia palustris (horned pondweed)

• Brackish tidal riverbank marsh system

Landscape settings: tidal riverbanks and near mouths of low-gradient coastal rivers feeding estuaries

Soils: marine peat and silt and clay; organic materials 16 to 50" thick overlying silty materials; oligo- to meso-haline (0.5-18 ppt); strongly minerotrophic

Spatial pattern: large patch (extensive narrow-linear) along riverbanks (several to 50 m wide by 50 - 2000+ m long); linear zonation parallel to riverbank

Physiognomy: herbaceous, sparsely vegetated

Distribution: restricted to tidal sections of primarily Great Bay coastal rivers and large streams below the lowest dams

Description: Brackish tidal riverbanks are flooded by tidal seawater that is diluted by freshwater flowing in from the watershed above. They consist of low and high brackish tidal riverbank communities. ***Brackish marsh***, another type of estuarine marsh occurring in oligo- to meso-haline soil water settings, may occur intermittently along the upper edge of the high brackish riverbank marsh. ***Low brackish tidal riverbank marshes*** typically occur in zones between mean sea level and mean high tide along moderate to steep brackish tidal river- and stream-banks. The hydroperiod (duration and frequency of tidal flooding) in ***low brackish tidal riverbank marshes*** roughly corresponds to that found in the low salt marsh, whereas soil water salinity is more equivalent to brackish marshes (0.5-18 ppt). Fresh water can form a lens on top of the seawater, causing salinity to fluctuate widely with the tides. ***High brackish tidal riverbank marshes*** typically occur as narrow zones along moderate to steep brackish tidal river- and stream-banks flooded less than daily (e.g., between the mean high water mark and the upper reaches of spring tides). The hydroperiod of ***high brackish tidal riverbank marshes*** corresponds to that found in the high salt marsh, whereas soil water salinity is more equivalent to brackish marshes (0.5-18 ppt). Where slopes are gentler, the low and high marshes may cover broader areas.

Much of the high and low marsh soil along stream and river mouths entering the Great Bay complex and the narrow margins around the bay consists of organic materials 16 to 50" thick overlying silty materials. Some stretches of riverbank consist of marine silt or clay, and gravelly or cobbly material is found along upper sections of large streams corresponding to this system.

Numerous rare plants that occur in brackish tidal riverbank marsh systems but not in salt marsh systems are diagnostic (listed below). *Spartina alterniflora* (smooth cord-grass) typically dominates the physically stressful low marsh. As salinity decreases, *Scirpus robustus* (stout bulrush) and *Typha angustifolia* (narrow-leaved cattail) become more prominent and may dominate the low marsh in some examples. A variable mix of graminoids and forbs characterize the high marsh zone.

Diagnostic natural communities:

- Low brackish tidal riverbank marsh (S1S2)
- High brackish tidal riverbank marsh (S1S2)

Peripheral or occasional natural communities:

- Brackish marsh (S2S3)

Associated natural community systems: This system may grade into sparsely vegetated intertidal and subtidal systems toward the channel and upland forest or freshwater stream borders landward or upstream.

Characteristic species:

Dominant to locally abundant species:

Spartina alterniflora (smooth cord-grass)
Scirpus robustus (stout bulrush)
Typha angustifolia (narrow-leaved cattail)

Other common species:

Aster novi-belgii (New York aster)
Spartina patens (salt-meadow cord-grass)
Juncus gerardii (salt marsh rush)
Typha angustifolia (narrow-leaved cattail)
Spartina pectinata (fresh-water cord-grass, slough-grass)
Agrostis stolonifera (marsh creeping bent-grass)
Carex paleacea (chaffy salt sedge)
Solidago sempervirens (seaside goldenrod)
Scirpus pungens (three-square rush).

Characteristic rare plants:

Limosella australis (Atlantic mudwort)*
Lilaeopsis chinensis (eastern lilaeopsis)*
Tillaea aquatica (pygmy weed)*
Samolus parviflorus (false water pimpernel)*

• Sparsely vegetated intertidal system

Landscape settings: partially protected, intertidal coastal embayments

Soils: fine to coarse mineral and rocky substrates; moderately to strongly minerotrophic

Spatial pattern: large patch, extensive narrow-linear to extensive fringes; 10 - 1000+ m long lengths of shoreline; uniform or narrow zonation parallel to shore

Physiognomy: sparsely vegetated

Distribution: restricted to the Great Bay estuarine complex, tidal coastal rivers, and other tidal embayments

Description: This system corresponds to intertidal areas with sparse vascular vegetation that occur between salt marsh, brackish marsh or upland systems landward and subtidal systems seaward. They include partially protected intertidal shores along rivers and other embayments; coastal shoreline strand/swales on coarse to fine mineral sediments; intertidal rocky shores on rocky or cobbly materials; and intertidal mudflats on broad to narrow, nearly flat extents of sand, mud, and silt. Vascular plant cover is sparse to generally no more than 25%.

Coastal shoreline strand/swales are flooded less than daily and are often characterized by plant stems and other detritus washed in on the higher tides and covering much of the substrate surface. These upper intertidal areas form either large patches or narrow strands along protected low-energy shorelines and are important habitat for various arthropods, shore birds, and other animals.

Intertidal rocky shores are on open stretches of estuarine rivers and streams or quiet, partially enclosed shores. They are flooded daily by tides. Macroalgae are often common on bedrock and rubble including *Ascophyllum nodosum* on larger outcrops and *Fucus vesiculosus* on less stable strata. Rocky shores may form large patches or narrow strands below the upper intertidal shoreline and are important habitat for various arthropods, predatory fish, wading birds, mud snails, and other animals.

Saline/brackish intertidal flats are gently sloping, sparsely vegetated areas between salt or brackish marshes landward and subtidal communities seaward (including tidal creek channels). They form in depositional environments protected from high-energy wave action along the coast behind rocky spits, barrier beaches, and sand bars or along bays and rivers. These flats have a great diversity of taxonomic groups and constituent species represented, including benthic diatoms and microalgae (important contributors to the estuarine primary productivity), invertebrates (including polychaete worms and mollusks), and Arthropods (green crabs, rock crabs, flat-clawed hermit crabs, and horseshoe crabs). During the diurnal (twice daily) tidal flooding several species of fish and other aquatic species feed on the benthos and epibenthic algae. This community also provides important foraging habitat for shorebirds and other animals when the intertidal flat is exposed. The diverse variety of primary foods (microalgae, phytoplankton, and detritus) available to consumers supports the high productivity found on intertidal flats. Macroalgae is typically uncommon across the exposed substrate.

Diagnostic natural communities:

- Coastal shoreline strand/swale (S2)
- Intertidal rocky shore (S3)
- Saline/brackish intertidal flat (S3)

Associated systems: This system occurs between salt marsh systems, brackish tidal riverbank marsh systems or upland communities landward and subtidal systems seaward.

Characteristic species:

Coastal shoreline strand/swales:

Spergularia marina (seabeach sand-spurrey)
Salicornia europaea (common glasswort)
Suaeda linearis (southern sea-blite)
Limonium carolinianum (sea lavendar)
Puccinellia maritima (seaside alkali-grass)

SUBTIDAL

This system corresponds to subtidal areas that occur almost exclusively below mean low tide. Upper subtidal reaches of may be briefly exposed during the lowest spring tides. Vascular plants are typically absent or sparse in subtidal systems; seaweeds, eelgrass, and oysters are important diagnostic biota.

• Subtidal system

Landscape settings: lowest (subtidal) portions of coastal embayments

Soils: mineral sediments and mud; strongly minerotrophic, saline to brackish

Spatial pattern: large patch, extensive flats to narrow-linear (100s of acres); broad patches, linear, and irregular zonation

Physiognomy: sparsely vegetated to unvegetated

Distribution: restricted to the Great Bay estuarine complex, tidal coastal rivers, and other tidal embayments

Description: This system corresponds to subtidal areas that occur almost exclusively below mean low tide, although upper reaches may be briefly exposed during the lowest spring tides. In New Hampshire, subtidal systems include the saline/brackish subtidal channel/bay bottom, tidal creek bottom, eelgrass bed, and oyster bed communities. This system performs important ecological functions including supporting oyster, eelgrass, and flounder populations, providing refuge for fish and invertebrates that retreat from exposed eelgrass beds, intertidal flats, and estuarine marshes at low tide, and serving as spawning and nursery areas for numerous species of aquatic animals (Short 1992). Vascular plants are typically absent or sparse in this system. Seaweeds are an important component of channel/bay bottoms and their surrounding environments. A total of 169 seaweed species have been documented as occurring in the Great Bay Estuary (Mathieson and Penniman 1991). Eelgrass beds dominated by *Zostera marina* (common eelgrass) occur in estuarine waters on mud rich in organic matter or on sand bottoms. This rooted aquatic vascular plant covers nearly half of the bottom of Great Bay (2585 acres). Eelgrass beds trap sediments, dissolved nutrients, and larval organisms flowing through the community and are an important contributor to ecosystem health and productivity. They serve as breeding, nursery, and feeding areas for many species of fish and invertebrates. Eelgrass beds also provide foraging grounds for waterfowl and wading birds that feed on the eelgrass or the fish and invertebrates the beds harbor. *Crassostrea virginica* (oyster) beds occur in shallow mixohaline estuarine waters of Great Bay. Oysters are an important food source for many other animals including starfish, crabs, fishes, and waterfowl.

Diagnostic natural communities:

- Saline/brackish subtidal channel/bay bottom (S3)
- Tidal creek bottom (S3)
- Eelgrass bed (S1)
- Oyster bed (S2?)

Associated natural community systems: Subtidal systems are bordered landward by sparsely vegetated intertidal systems, and seaward beyond the channel mouth by the marine environment.

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Appendix 1. Explanation of global and state rank codes.

Ranks describe rarity both throughout a species' range (globally, or "G" rank) and within New Hampshire (statewide, or "S" rank). The rarity of sub-species and varieties is indicated with a taxon ("T") rank. For example, a G5T1 rank shows that the species is globally secure (G5) but the sub-species is critically imperiled (T1).

Code	*Examples*		*Description*
1	G1	S1	Critically imperiled because extreme rarity (generally one to five occurrences) or some factor of its biology makes it particularly vulnerable to extinction.
2	G2	S2	Imperiled because rarity (generally six to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction.
3	G3	S3	Either very rare and local throughout its range (generally 21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction because of other factors.
4	G4	S4	Widespread and apparently secure, although the species may be quite rare in parts of its range, especially at the periphery.
5	G5	S5	Demonstrably widespread and secure, although the species may be quite rare in parts of its range, particularly at the periphery.
U	GU	SU	Status uncertain, but possibly in peril. More information needed.
H	GH	SH	Known only from historical records, but may be rediscovered. A G5 SH species is widespread throughout its range (G5), but considered historical in New Hampshire (SH).
X	GX	SX	Believed to be extinct. May be rediscovered, but evidence indicates that this is less likely than for historical species. A G5 SX species is widespread throughout its range (G5), but extirpated from New Hampshire (SX).

Modifiers are used as follows.

Code	*Examples*		*Description*
Q	G5Q	GHQ	Questions or problems may exist with the species' or sub-species' taxonomy, so more information is needed.
?	G3?	3?	The rank is uncertain due to insufficient information at the state or global level, so more inventories are needed. When no rank has been proposed the global rank may be "G?" or "G5T?"

When ranks are somewhat uncertain or the species' status appears to fall between two ranks, the ranks may be combined. For example:

G4G5	The species may be globally secure (G5), but appears to be at some risk (G4).
G5T2T3	The species is globally secure (G5), but the sub-species is somewhat imperiled (T2T3).
G4?Q	The species appears to be relatively secure (G4), but more information is needed to confirm this (?). Further, there are questions or problems with the species' taxonomy (Q).
G3G4Q S1S2	The species is globally uncommon (G3G4), and there are questions about its taxonomy (Q). In New Hampshire, the species is very imperiled (S1S2).

Appendix 2. Explanation of state listing codes.

In 1987, the New Hampshire state legislature passed the Native Plant Protection Act (RSA 217-A) and formally recognized that "for human needs and enjoyment, the interests of science, and the economy of the state, native plants throughout this state should be protected and conserved; and . . . their numbers should be maintained and enhanced to insure their perpetuation as viable components of their ecosystems for the benefit of the people of New Hampshire." To compile a list of the species requiring protection, the NH Natural Heritage Bureau collaborated with knowledgeable botanists and identified the most imperiled taxa as "endangered" and those likely to become endangered as "threatened." A total of 288 taxa were listed, 144 as endangered and 144 as threatened.

In addition to endangered and threatened categories, a state watch category exists for taxa appearing vulnerable to extirpation where current information does not justify designating them endangered or threatened.

Endangered

Native plants documented as having five or fewer natural occurrences in the state observed within the last 20 years, or plants with more than five occurrences that are, in the judgment of experts, critically imperiled by extirpation due to other important rarity considerations (number of individuals, area of population occupancy, restrictiveness and distribution of species' geographic range, habitat rarity, population trends, population viability, and degree of protection).

Threatened

Native plants documented as having 6-20 natural occurrences in the state observed within the last 20 years, or plants with more than 20 occurrences that are, in the judgment of experts, imperiled by extirpation due to other important rarity considerations (number of individuals, area of population occupancy, restrictiveness and distribution of species' geographic range, habitat rarity, population trends, population viability, and degree of protection).

Watch

Native plants documented as having 21-100 natural occurrences in the state observed within the last 20 years, or plants that are, in the judgment of experts, vulnerable to extirpation due to other important rarity considerations (number of individuals, area of population occupancy, restrictiveness and distribution of species' geographic range, habitat rarity, population trends, population viability, and degree of protection). Native plants whose status is uncertain, but are possibly in peril, may be designated state watch as well.

Rare (endangered and threatened) species listed in this document are followed by an asterisk(*).